MANAGEMENT BY OBJECTIVES

CONSTRUCTION PROJECT PRODUCTION PLANNING

- general systematics
  NBR model


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Construction project production planning

- general systematics
  NBR model

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0 PREFACE

THIS BOOK DESCRIBES THE SYSTEMATICS OF PRODUCTION PLANNING OF A CONSTRUCTION PROJECT (ROAD CONSTRUCTION MAINLY). AS BACKGROUND FOR PROJECTS PRODUCTION PLANNING IN THE BEGINNING OF THIS BOOK THERE IS A SHORT DESCRIPTION OF 3-YEAR OPERATIVE PLANNING.

MOST PART OF THIS BOOK DEALS WITH PRODUCTION PLANNING OF A CONSTRUCTION PROJECT. PRODUCTION PLANNING ON A PROJECT STARTS BEFORE THE ACTUAL CONSTRUCTION WORKS START (PRETENDERING AND TENDERING PLANNING) AND IT CONTINUES UNTIL THE END OF THE PROJECT.

WORK SITE PLANS ARE DRAWN UP WHEN THE PROJECT STARTS AND THEY ARE REVISED ACCORDING TO THE ACTUAL CONDITIONS ON THE WORK SITE BEFORE THE WORKS START.

1. INTRODUCTION

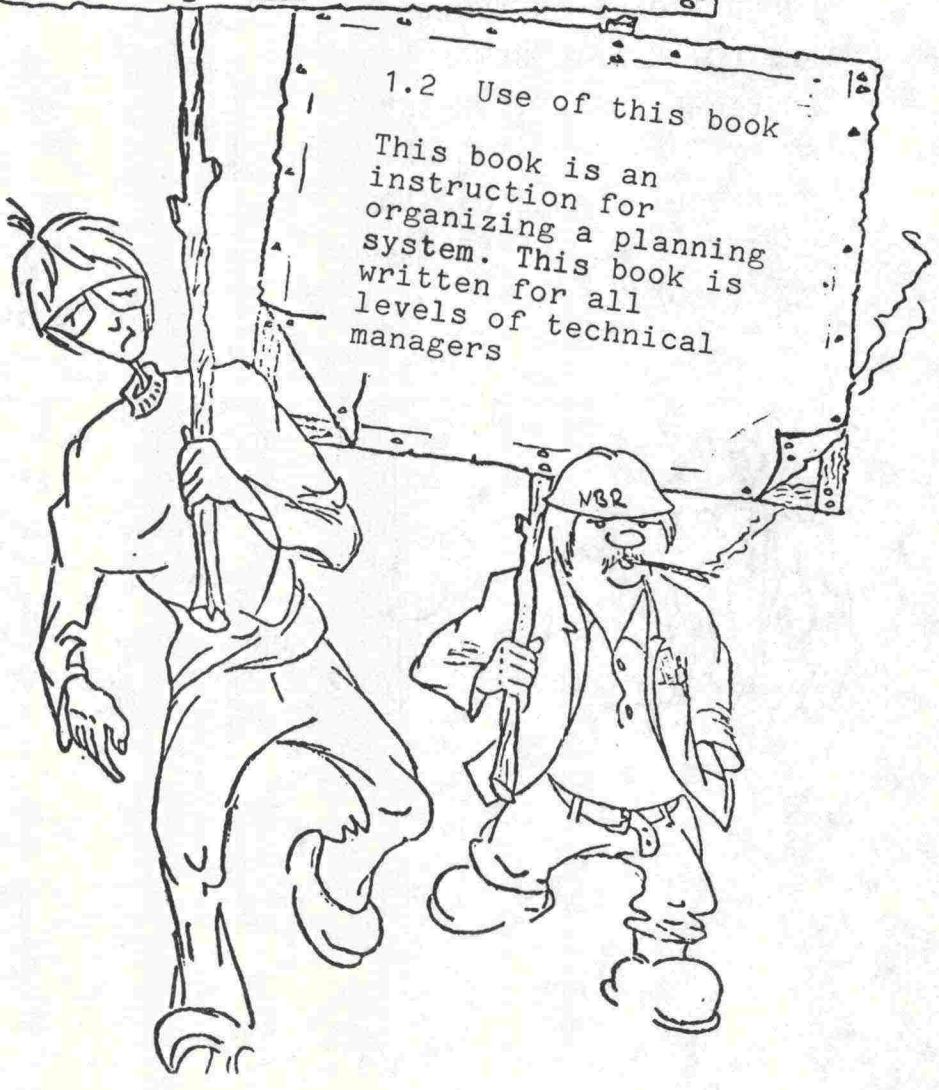
1.1 The objectives of production planning

Production planning of a construction project aims at finding the most economical way of carrying out the project. Production planning is choosing the way of carrying out the project by doing alternative calculations under restraints set by nature and management.
Production planning includes
- choosing the work sites
- scheduling the project
- choosing the work methods
- choosing the resources (machinery, labour, material)
- cost calculations
- budgeting

The production plans are expressed in tables and charts (schedules) and the production plan is the basic document of managing, reporting and controlling a construction project

1.2 Use of this book

This book is an instruction for organizing a planning system. This book is written for all levels of technical managers



2. THE 3-YEAR OPERATIVE PLANNING OF THE CONSTRUCTION DIVISION (NBR)

Purpose:

The purpose of the 3-year operative planning is to optimize the activities of the construction division as a whole by:

- making the most appropriate combinations of various projects
- scheduling the projects in the most optimum way bearing in mind the conditions which will affect on the execution of the projects and the available resources
- influencing the plans and programs of the higher level, if necessary
- bringing the plans and programs up to date so that it would be easy to adjust to the changes in the frames and to give data to other plans
- giving clear and premeditated frames for programming the projects.

Presumptions

As a presumption for applying the 3-year operative planning is that the top management will determine the business idea and goals for the district. With these the management will formulate the policies and the more detailed objectives.

The management of the construction division must give the objectives to the division according to the objectives of the whole district.

Also the policies for the division should be discussed in order to help to manage the division.

The complete benefit of the 3-year operative planning will be drawn if the goals are clear and the plans will meet the objectives of the division.

Frames

The chief of the construction division (chief engineer) will get the projects for the 3-year operative plan form long range plans (5-year) and the annual cost frames also. After he has got the objectives given by the management of the district then he can give the projects for the project managers and he gives each his own frames for the execution of the projects.

Process of planning in the construction division

The process on the 3-year operative planning is presented in fig. 1.

After the chief engineer has given the frames to the project managers they will draw up their own 3-year operative plans. The plans of every project manager will then be discussed and fitted together so that they will meet the objectives set for the division.

As a result of this planning one will get the 3-year operative plan for the construction division. It will include e.g. costs of the projects and personnel and labour plans.

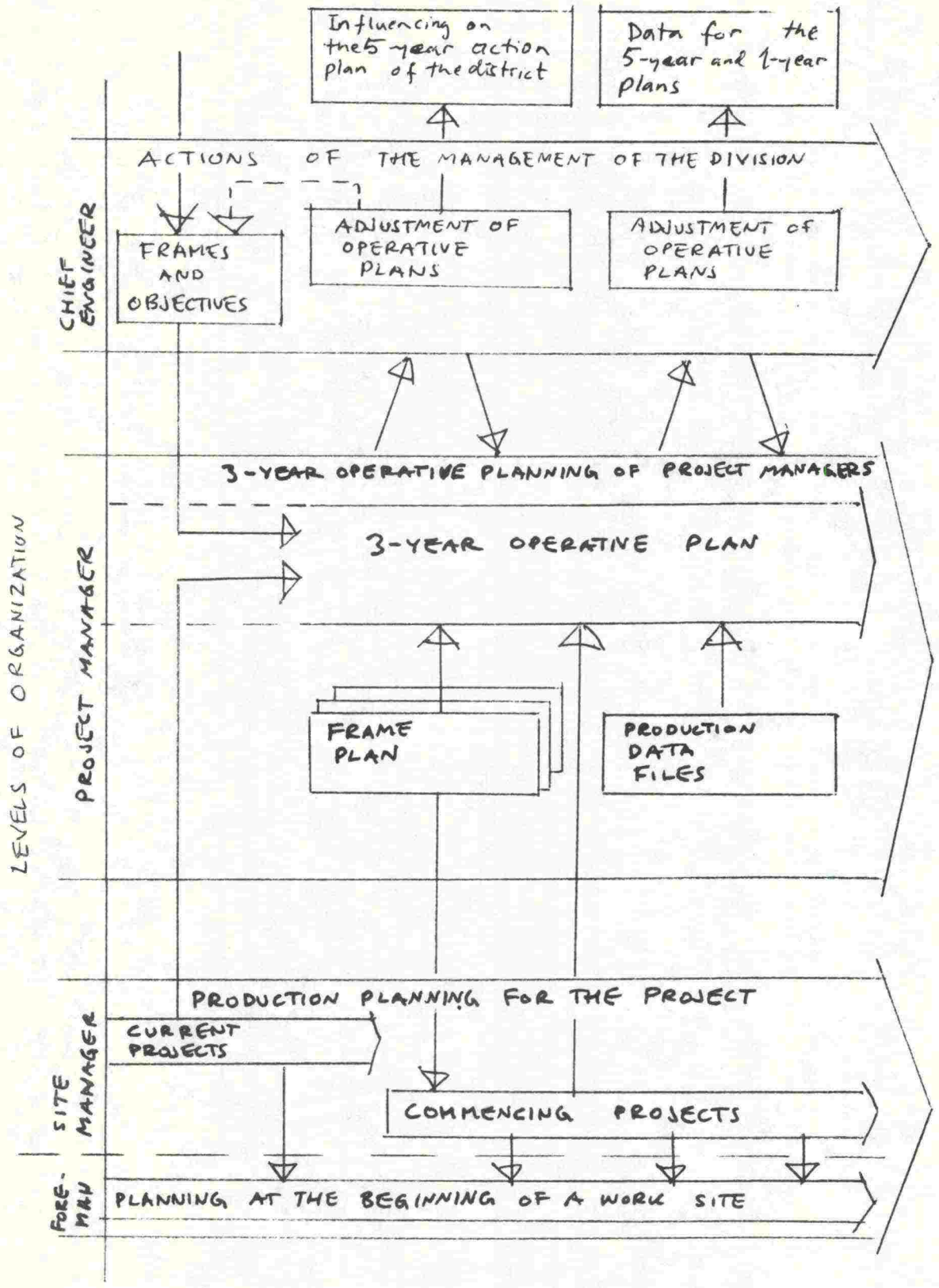


Figure 1. The process of 3-year operative planning

The 3-year operative plan will be kept up to date continuesly. Changes will occur in the plans if for example the frames and the product plans (drawings) will be changed or if there are any major changes in the current projects in operation.

Use of the plans in the operative planning of the district

One will get up to date data from 3-year operative plans for other plans in the district and also for various plans of the whole NBR.

In fig. 2 you will see how one project is handled in the 3-year operative plan of a project manager.

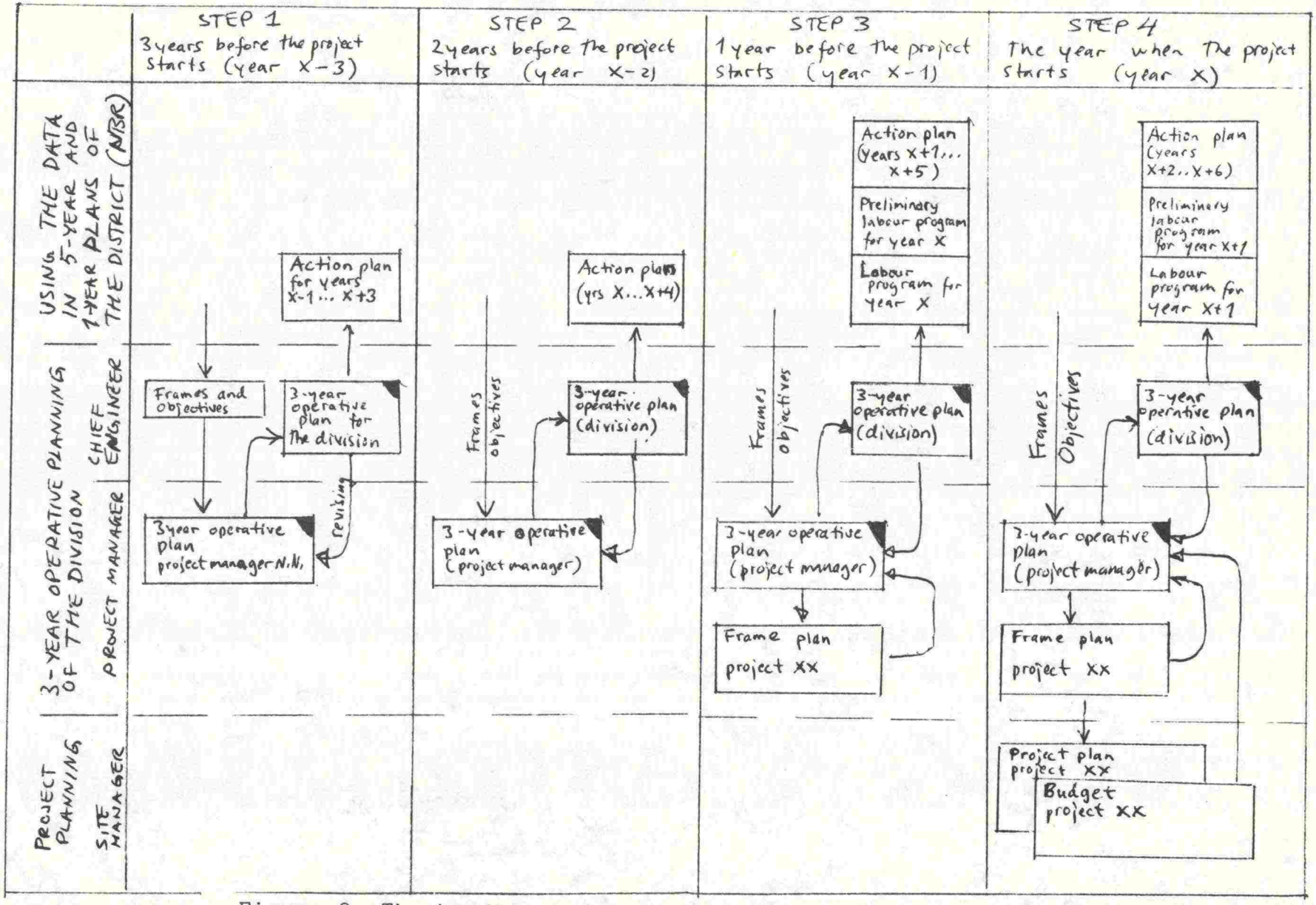
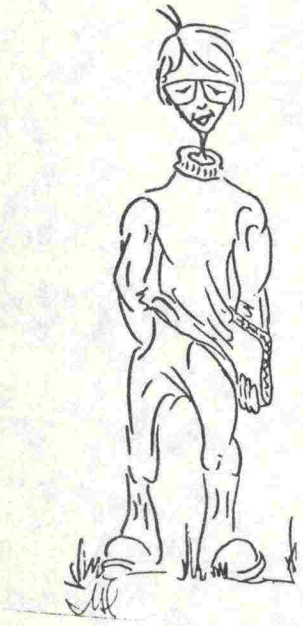


Figure 2. The handling of a project in the 3-year operative planning

3. PRODUCTION PLANNING ON A CONSTRUCTION PROJECT

3.1 Basic documents

Production planning starts so, that first the project manager draws up the roughest production plan called frame plan. Production planning continues so that next the site manager draws up the rough production plan. Third step of production planning is the making of the final production plan by the site manager and foremen. The last step of production planning is the very short range planning called weekly work planning and work site planning.



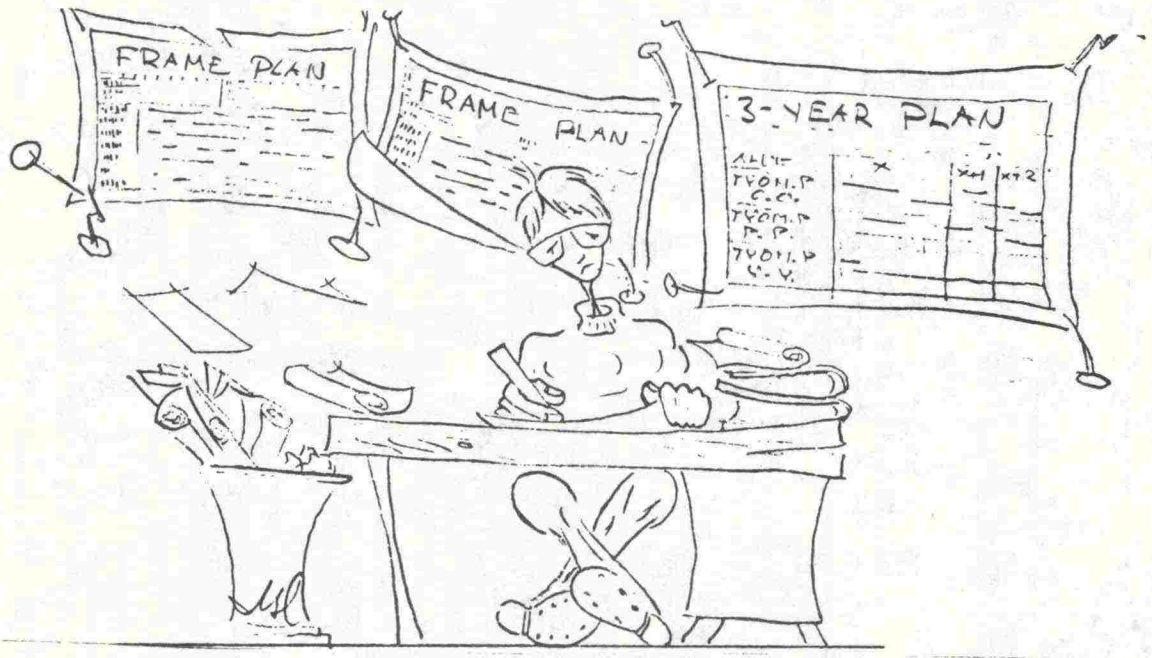
The frame plan can be made according the rough tendering documents:

- maps
- Bill of Quantities on major parts
- longitudinal & cross sections
- the general data about the project
  - a summary of basic data needed on planning and carrying out the project
- data about material refining places
- transportation routes (access roads).

The more thorough steps of production planning should be based on the same documents as listed above and also:

- the production plans made before
- general specifications
- contract program
- plan drawings
  - cross sections
  - longitudinal sections
  - maps
  - special works
- accurate bill of quantities (on specific cost codes).

3.11 The frame plan



The frame plan is the roughest production plan that is ment to optimize the use of resources on a project.

The frame plan is made by the project manager. In this plan he chooses the optimum machinery and schedules the project and the work sites that he is responsible for.

In frame planning the project manager plans his actions and his policies for the whole duration of the project. The plan includes all major works.

The frame plan is based on rough product plans and quantities that are based on rough accuracy.

The frame plan of a project includes:

- the rough schedule of the project
- the main methods to be used
- the works that are planned in the district office (crushing, pavement...)

FRAME PLAN

COMPANY

DISTRICT	No	NAME	DATE	PROJECT MANAGER	DATE	DISTRICT MANAGER
PROJECT	No	NAME				

DESCRIPTION OF THE PROJECT (cross section, pavement, concrete, steel ...)

COSTS AND LABOR

YEAR	19	19	19	19	19	19	
(1000 FIM)							
Labour							
Cost index							

MONTHLY 19 jo. 19

	1	2	3	4	5	6	7	8	9	10	11	12
(1000 FIM)												
Labour												
(1000 mk)												
LABOUR												

THE SCHEDULE OF THE PROJECT AND ORGANIZATION

COST CODE	Name of cost code works	UNIT	QUANTITY	UNIT COST	TOTAL COST	MONTHLY SCHEDULE	COMMENTS
	TOTAL						
	ORGANIZATION				site manag. foreman laboratory office warehouse		

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Figure 3. The frame plan sheet

FRAME PLAN

COMPANY MECCO

DISTRICT	No	NAME	DATE 1980-04-13	PROJECT MANAGER:	DATE	DISTRICT MANAGER
PROJECT	No 1	NAME				

DESCRIPTION OF THE PROJECT (cross section, pavement, concrete, steel ...)

COSTS AND LABOR

YEARLY	1978	1979	19	19	19	19	Σ
(1000 shillings)	349	2301					3150
Labour	90	213					
Cost index	230	230					230

MONTHLY 1978 to 1979	1	2	3	4	5	6	7	8	9	10	11	12
(1000 shil)	—	—	—	—	—	—	—	—	188	256	235	170
Labour	—	—	—	—	—	—	—	—	20	25	25	20
(1000 mk)	219	213	120	—	54	141	281	312	732	224	—	—
LABOUR	20	20	15	—	10	20	30	30	45	25		

THE SCHEDULE OF THE PROJECT AND ORGANIZATION

COST CODE	Name of cost code works	UNIT	QUANTITY	UNIT COST	TOTAL COST 1000 Shillings	MONTHLY SCHEDULE 1978 Sept	Oct	Nov	Dec	1979 1	2	3	4	5	6	7	8	9	10	COMMENTS
1110	Removal works				150,0	5000 / 30	5000 / 10			30	30				20	80				
1120	Clearing works	m²	31400	2,00	62,8	5000 / 10	5000 / 10	5000 / 10	5000 / 10	2000 / 6	2000 / 6			1000 / 2	2700 / 5	1900 / 3				
1310	Ditching	m3	2120	7,00	14,8															
1320	Underdrainage	m	1840	180,00	331,3	240 / 43	480 / 32	7000 / 54												
1330	Culverts	m	50	200,00	10,0			50 / 10												
1500	Constr. rock formation	m³	44000	9,00	394,2	6000 / 84	7000 / 63	7000 / 63												
1610	Filter course	m³	13100	18,00	235,8		1100 / 20	1100 / 20												
1620	Sub-base course	m³	5500	20,00	110,0		733 / 15	733 / 15												
1630	Base course	m³	5000	24,00	120,0															
1720	Asphalt pavement	*	29200	13,5	394,2															
1800	Equipment	—	[illegible]	[illegible]	583,6	510	30	320												
1900	Crushing	m3	10600	9,50	100,7															
9200	Common costs	—			637,6	45	63	60	40	44										
Σ	TOTAL				3150,0	188	256	235	170	218										
	ORGANIZATION				site manag.	1	1	1	1	1	1	1	—	1	1	1	1	1	1	
					foremen	3	3	3	3	3	3	2	—	1	2	3	4	4	3	
					laboratory	1	1	1	1	1	1	1	—	1	1	1	1	1	1	
					office	1	1	1	1	1	1	1	—	1	1	2	2	2	1	
					warehouse	1	1	1	1	1	1	1	—	1	1	1	1	1	1	

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Figure 4. The frame plan of a project

- costs of the project and need for labour
- data on main machinery
- data on getting energy (electricity)
- data on work site area planning

3.2 THE PROCESS OF PRODUCTION PLANNING

The process of production planning after the frame plan includes several steps (figure 5)

- Getting acquinted with the basic documents available for the project
- The rough production planning
- The final production planning
- Work site planning in the beginning of the site

Getting acquinted with the basic documents:

The project manager and the site managers go over the frame plan together. They compare the frame plan to the latest product plan drawings and to the actual site conditions.

If there are differences between the frame plan and drawings or conditions, they should be written down. This way the differences can be taken into consideration in further production plans.

The rough production planning

The rough plans are made when the project is know to be starting in the near future

PROCESS OF PRODUCTION PLANNING IN A CONSTRUCTION PROJECT

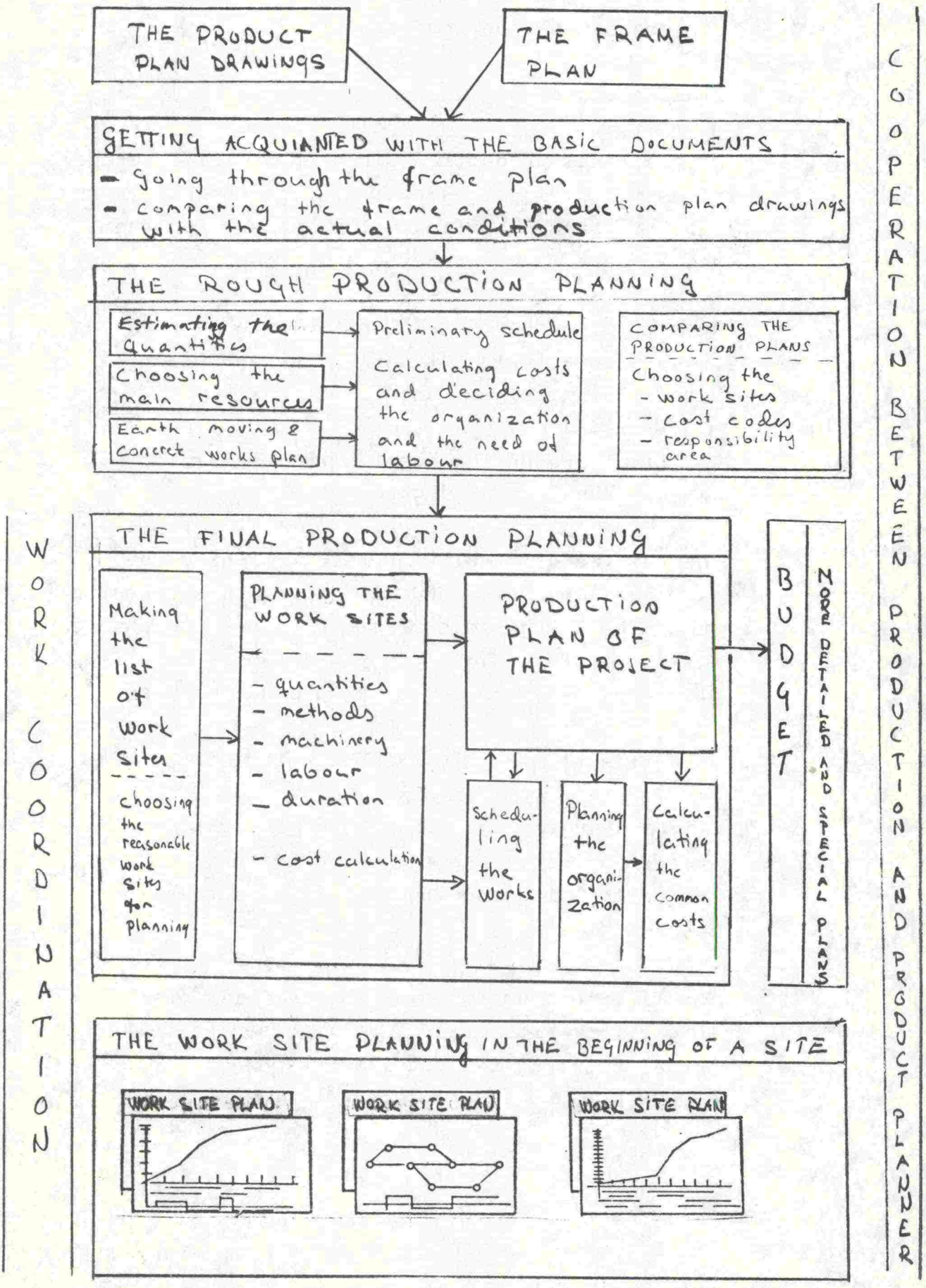


Figure 5. The process of production planning

By doing the rough plan the site and project manager can settle out all their differences about carrying out the project. This way they get a common model for organizing the project.

The final production planning

In the final production planning the site manager plans all his actions that are needed in carrying out the works. The final plan is made for the whole duration of the site and project.

According to the final plan the site manager can coordinate all his actions and purchases of materials, machinery and labour.

The final production plan is the basic model of carrying out the project on site.

The results of final production planning are expressed on tables and schedules. These results should be reorganized if there is need to change the plan later on. The budget and more detailed plans are based on the final production plan.

The work site planning in the beginning of the site

Before starting the works on a site the site manager or site foreman goes over the final production plan checking how it effects this beginning site.

The site manager reorganizes the final plan into a work site plan, that is based on the actual construction conditions and available machinery.

There might be some changes from the final plan to the work site plan.

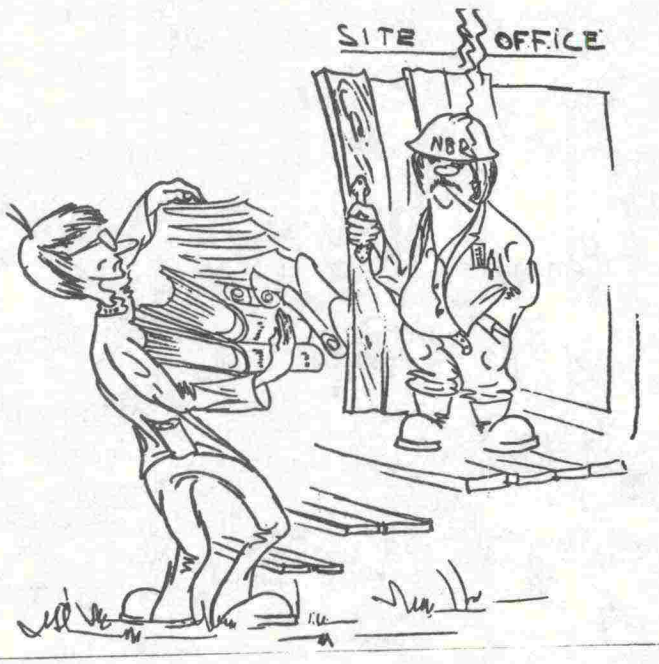
The work site plan should be done according to alternative cost calculations.

3.3 GETTING ACQUINTED WITH THE BASIC DOCUMENTS AVAILABLE FOR THE PROJECT

Before the actual work planning process the planner has to do some of the following things.

Revising of the frame plan:

The project manager presents his frame plan to the site managers. The frame plan will form the basis on which the site managers has to lean when he does further production plans.



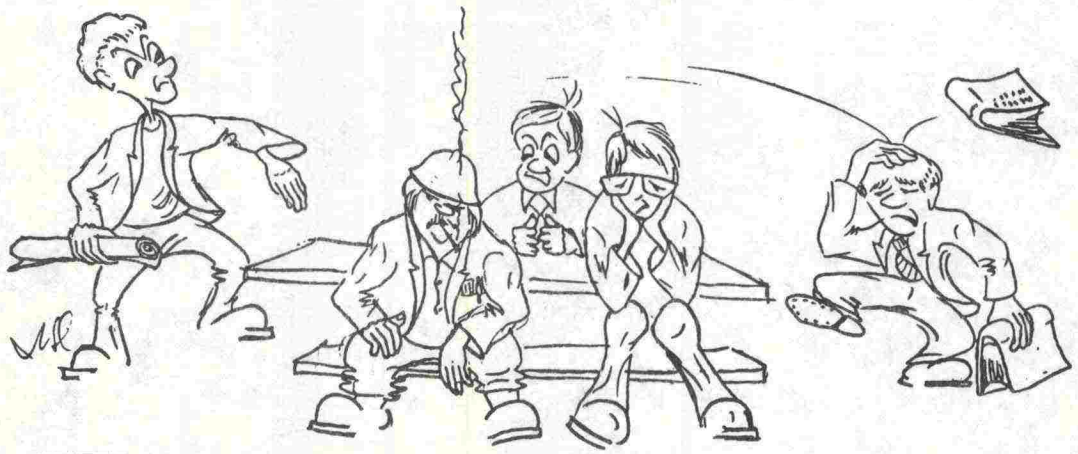
It is very important that in this stage the project manager gives the site manager all the information that he has got about the project and site.

The project manager also has to clear out all the things that have effected his decisions on schedule, methods and other things.

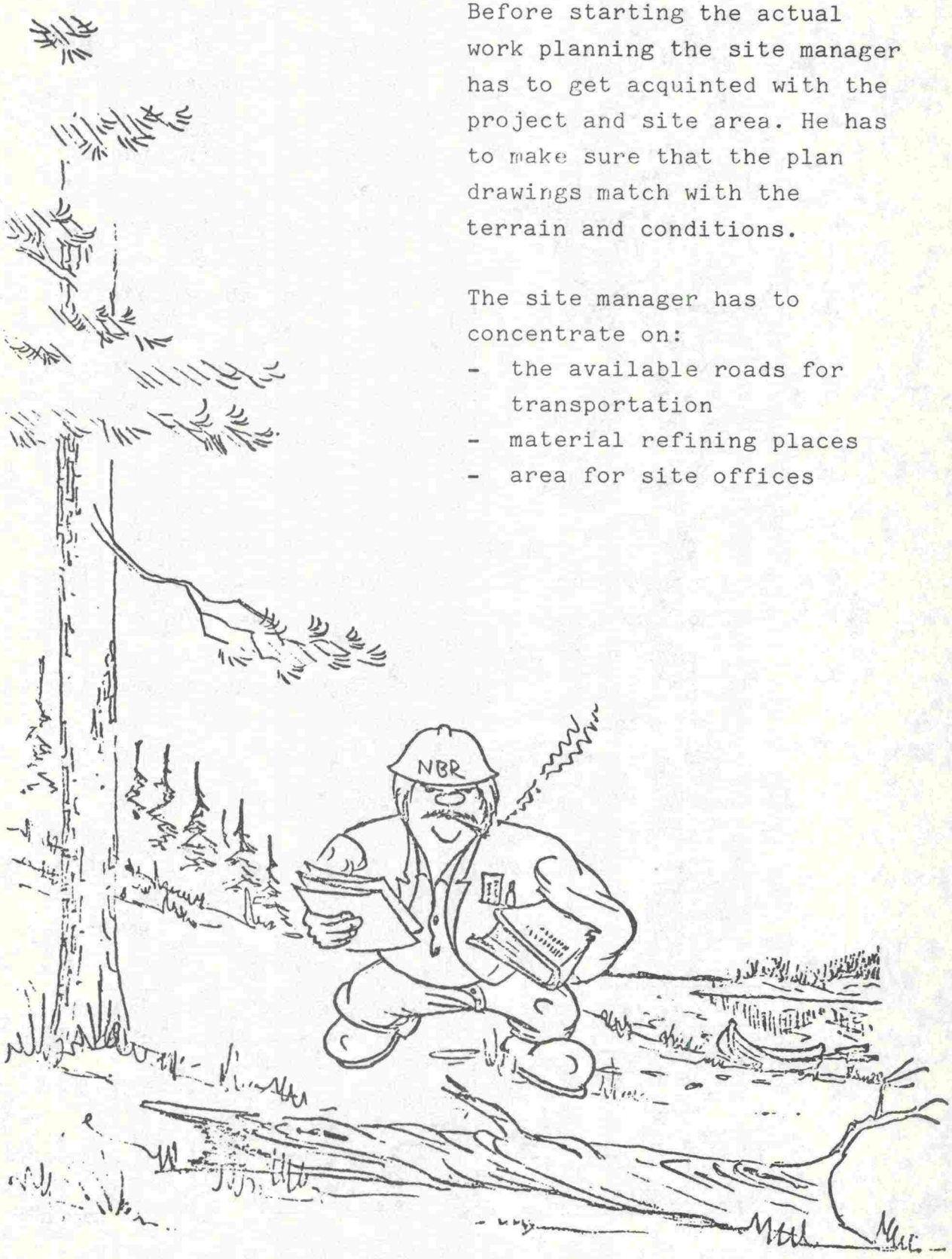
The project managers decisions can be affected by facts that concern the whole company and not only this project, for instance:

- stone crushing and pavement laying can be tied up to schedules of other projects
- the use of special resources
- the use of machines that there is a shortage of
- the use of labour
- the effects on organization.

In this stage the project manager also has to tell the site manager how the objectives of this site and project, effect the objectives of the whole company or its section (division).



Comparing the product plan drawings with the actual site area conditions



Before starting the actual work planning the site manager has to get acquinted with the project and site area. He has to make sure that the plan drawings match with the terrain and conditions.

The site manager has to concentrate on:

- the available roads for transportation
- material refining places
- area for site offices

3.4 ROUGH PLANNING

In the beginning of a project the site manager will get familiar with the project by making a rough plan of it.

In rough planning the site manager:

- will study the frames given by the project manager and propose the necessary changes
- will create the premises for the final planning and execution of the project.

The need and accuracy of rough planning depends on the size, duration and complexity of the project. So the rough planning will be carried out:

- by making the necessary changes in the frame plan of the project
- by drawing up the so called rough plan
- simultaniously with the final planning.

The rough planning will be executed as shown in fig. 6.

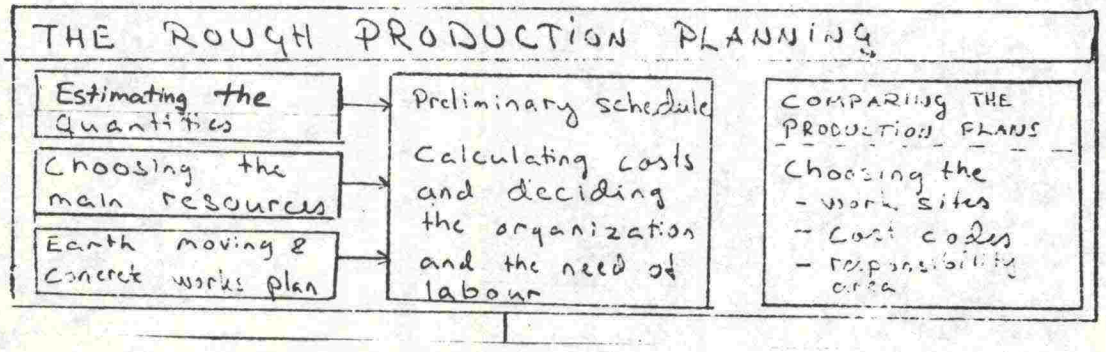


Figure 6. The process of rough production planning

3.41 Planning of mass-hauling

When making the drawings of a road construction project (product plans) one must study the economy of moving earth and rock masses in order to find right vertical alignment. The plans for using the masses are usually very rough in the product planning stage and they often are presented in diagrams.

When starting the rough planning one must have a clear and comprehensive picture of the mass hauling needed for the execution of the project. For this purpose the mass hauling or transportation plans are drawn up, or the existing plans (made by the designer) are revised by the site management.

In mass hauling planning one must take into consideration all affecting factors in order to prepare reliable plans. When planning the hauling one must be study:

- geotechnical conditions
- availability of the masses from route
- access roads (existing and planned)
- traffic
- schedule
- working methods and availability of machinery
- special works e.g. bridges, canals etc.
- other restrictions on site

Purpose of mass hauling planning

Hauling plan is the base for scheduling and cost calculations of a road construction project. Since the mass works usually represent a big part of the costs of the project the hauling plan should be reliable and feasible.

The purpose of hauling planning is that:

- the transportation cost of the masses will be minimized
  - This means that
    - there will be no unnecessary handling of the masses
    - stockpiling of masses should be avoided
    - all the useful masses will be used properly
- in the feasible solution one has taken into consideration the effect of different seasons on the construction
- the solution will show from where, in what sequence and how much masses will be hauled and what are the hauling distances including the borrow pits and tipping areas

Drawing up the hauling plan

The planning will start by dividing the masses into different groups for example:

- compulsory movings (movings which cannot be done otherwise e.g. short movings by bulldozer or wheelloader)
- masses to tipping area
- masses which are suitable for embankments
- rock masses
- refined masses (crushed stone etc.)

The masses must be changed into the same units e.g. the excavated masses will be changed from solid volume into loose volume (m^3). The conversion factors are given in production data files (NBR) or one can measure them on site.

CUTS (m^3)

FILLS (m^3) (structural)	C1	C2	B1 BORROW PIT	C3	C4	B2 BORROW PIT	C5	TOTAL VOLUME OF FILLS
F1	200 (200) ← 200 m^3 to be moved from cut 1 to Fill 1							200
F2	232 (150)	268 (450) ← distance in metres (from C2 to F2)						500
F3		164 (300)	236 (450)					400
F4			1404 (800)	196 (400)				1600
F5				236 (400)	540 (250)	1224 (1000)		2000
F6						430 (1600)	570 (400)	1000
TOTAL VOLUME OF CUTS	432	432	1640	432	540	1654	570	

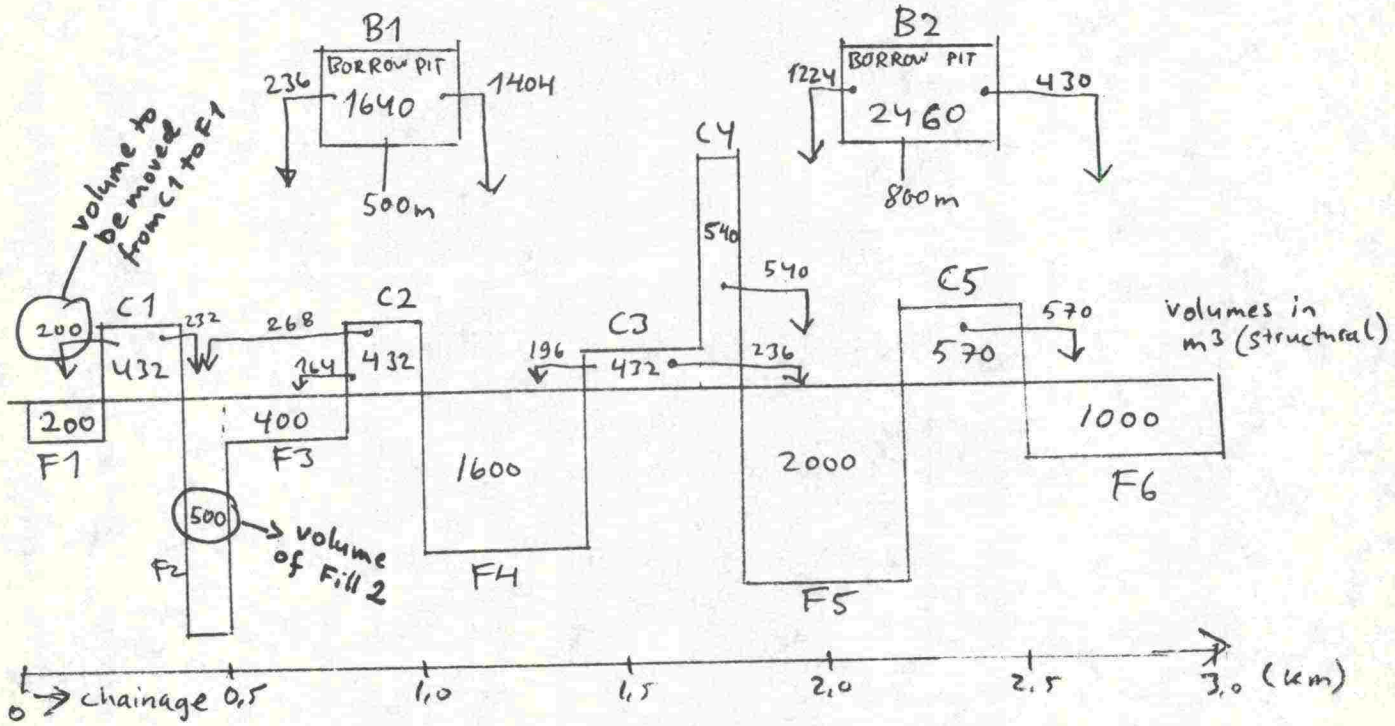


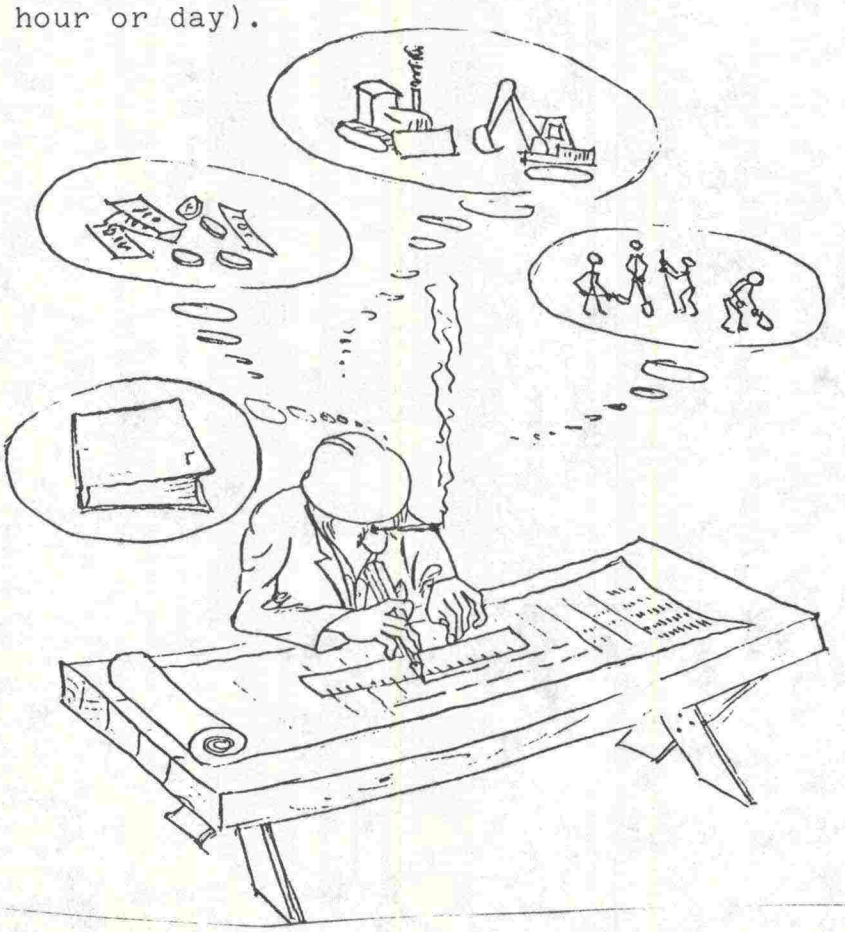
Figure 7. The mass hauling plan

The optimizing of the movings will be done by means of alternative calculations. The purpose of these calculations is to find out the most economic way of executing the haulings. For the calculations one must know the hauling cost of different kinds of masses (per unit) including the hauling cost according to the hauling distance. The optimizing process may be done by using mathematical methods (transportation problem, linear programming etc.).

3.42 Quantities and the main resources

From the list or bill of quantities one should get all of the quantities accurately enough to make the rough plans.

In order to determine the durations of various activities (works) and the cost, one should choose the right machinery (the main resources) and calculate their average out-put (quantity/ hour or day).



3.43 Rough scheduling; cost, labour and organization planning

In rough scheduling at first the dependencies between various activities should be solved with the restrictions caused by the seasons and other demands (e.g. the logical order of activities and the most economic time (season) for executing the activities). Taking the restraints into consideration the activities will be scheduled so that the use of machinery, labour and cost will be as even as possible or according to given restraints or set objectives. Below (fig. 8) is an example of a rough plan.

ROUGH PLAN

COST CODE	WORK	UNIT	QUANTITY	UNIT COST	TOTAL COST	1979 SEPT.	OCT	NOV	DEC	JAN
1110	Removal work	—			150 000	5000			30 000	70 000
1120	Clearing	m^2	31500	2,00	63 000					
1310	Ditching	m^3 s.l.d	2200	7,00	15 400					
1330	culverts	m	50	250,00	12 500					
1500	Excavation (earth)	m^3 solid	43800	9,00	394 200					
—	e. tc.	—	—	—	—	—	—	—	—	—
1720	Pavement, bit.	m^2	30 000	13,00	390 000					
1810	Installations	pieces	100	500,00	50000					
	TOTAL COST OF THE WORK				2'505800	123 000	163 000	183 700		
	COMMON COSTS (ca 26 %)				640000	50000/3	50000/3	55 000/3		
	GRAND TOTAL				3'145800	173 000	213 000	238 700		
	PERSONNEL OF THE PROJECT									
	Technicians					3	3	3		
	Foremen					2	2	2		
	Clerks					1	1			
	Stock workers					1	1			
	Labour incl. drivers					16	16			
	TOTAL LABOUR					23	23			

Figure 8. The rough plan

Since this is only rough planning the cost calculations may be done with for example standard costs. Still the most important activities should be calculated more accurately. The costs of common works may be calculated roughly or with standard costs.

In rough scheduling one must keep in mind the given restraints concerning the total cost, labour and organization.

3.44 Comparing and adjusting the frame plan and the rough plan

In discussions between the project manager and site manager, they will compare the rough plan with the frames given by the project manager. Also they will make agreements about the possible changes in the plan.

The adjustment will give new, more accurate frames for the final and detailed planning done on site.

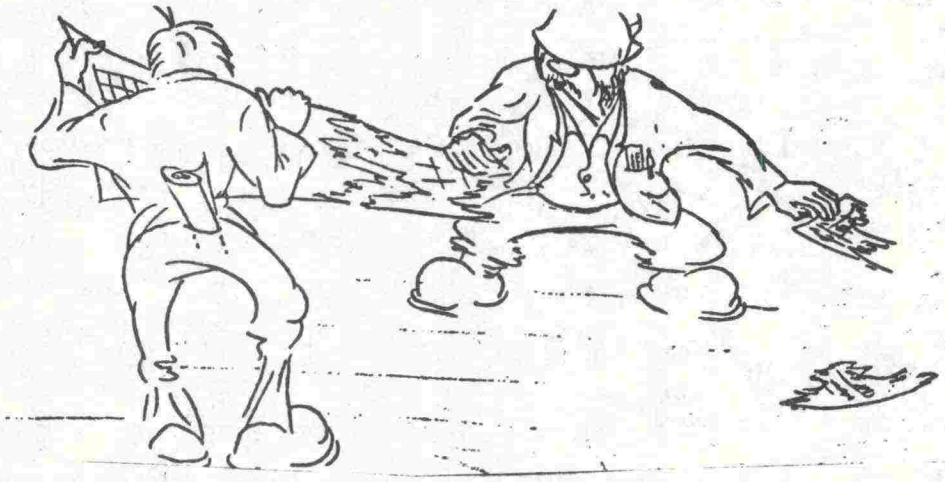
After this the project is divided into different responsibility areas, work sites and cost codes etc.

3.45 Break-down of the project

The purpose of the break-down of the project is to make the further planning and controlling easier. The break down will help:

- the managing of the project
- the managing of a work site
- cost accounting.

The break-down will determine the accuracy of the production plans and programs and control. Since the accuracy of control varies in the different levels of organization the project manager and the site manager must agree on the break-down.



The project will be divided into:

- (responsibility) areas
- items (or activities, cost codes)
- work sites.

Responsibility area

The responsibility areas should be determined so that cost code numbers will be the same throughout the duration of the project. By responsibility areas the project can be divided into parts, the cost of which can be followed separately.

The principles of dividing into responsibility areas (NBR) are:

- cost code (area) for common works is 00
- every bridge will be its own area in a road construction project
- work area which is supervised by one supervisor or foreman may be a responsibility area
- different parts of the road under construction may be responsibility areas.

Item (cost code)

In dividing the project into items (activities or cost codes) the cost code books for roads and bridges published by NBR will be used (publ. number TVH 732170 and TVH 732082).

The accuracy of the cost codes is chosen according to the needs of managing the project

- The project manager may decide that for example for cost accounting purposes some parts of the projects will be followed more accurately, and then the most detailded level of cost codes is used (from the books published by NBR).
- Every activity of the project need not to be on the same level of cost codes. The accuracy depends on the size and significance of the works.
- The activities which are very important concerning the scheduling and costs are followed more accurately.
- Using too rough level of cost codes should be avoided, because the more accurate level is not too laborious.

Work site

The site manager should determine the work sites for the project. After this the list of items/ work sites can be made.

Dividing into work sites is necessary when
- the same cost code (item) includes works that have very different unit costs or the circumstances for execution differ much
- the works included in a cost code are executed in many parts and vary in respect of schedule and work method.

Cost codes in a project

Cost codes are used for cost accounting and cost controlling.

In the NBR the cost code includes 12 digits:

- Project number	3 digits
- Responsibility area	2 digits
- Item (cost code or account)	4 digits
- Work site	2 digits
- Type of cost	1 digit

The work is divided into 7 types of costs:
- labour
- machinery
- transport
- material
- contract (total, turn key)
- subcontracts
- others.

Cost calculations in work site planning may be made by types of cost, but in a work plan and in a budget the type of cost is not shown. Cost accounting system can divide the costs to the types of cost.

3.5 FINAL PLANNING AND PROGRAMMING

The purpose of the final planning is to produce a model for executing the project.
At this stage the most useful ways of executing the works will be figured out in respect of technics and economy.

In final planning and programming:

- the lists of work sites are to be prepared according to the break down of the project and lists of items
- work site plans are to be prepared
  - one will choose the best working methods and machines and calculate the durations and costs of the work sites (according to the lists of work sites)
- work plan for the project is prepared in respect of the given restraints for the scheduling and the use of resources.

The process of the final planning and programming is shown in fig. 9.

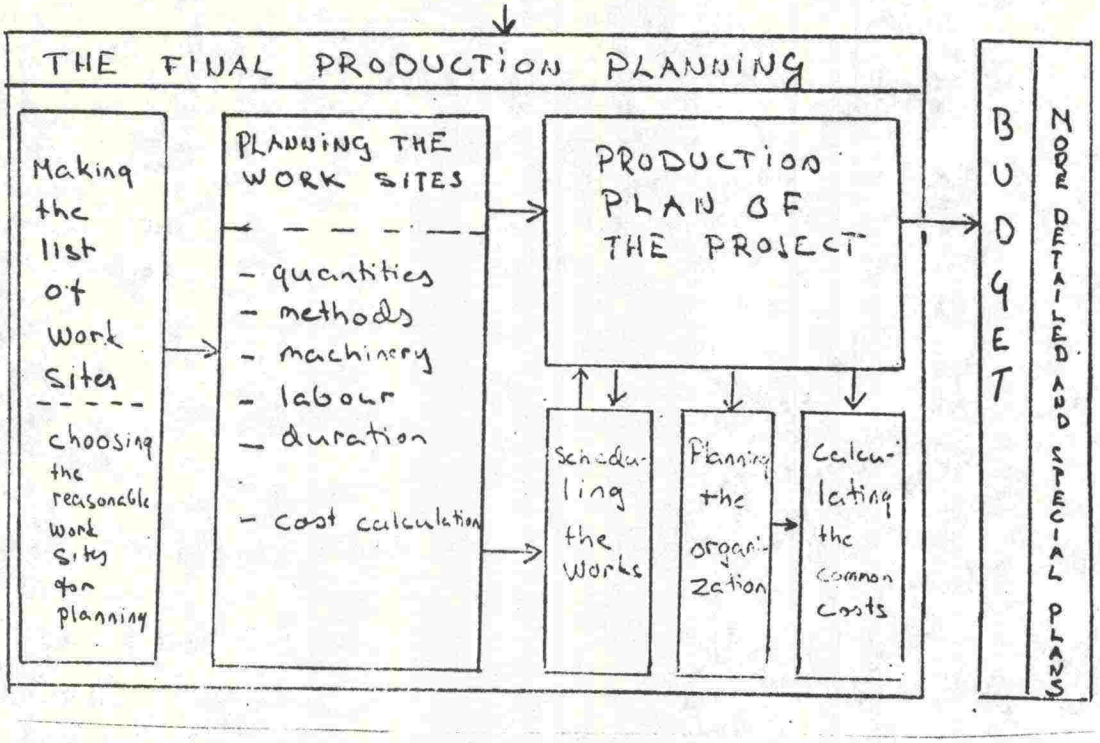


Figure 9. The process of final production planning

3.51 List of work sites

While drawing up the construction plans (drawings) the designer will fill up the list of quantities (Bill of Quantities)(fig. 10).

The list of work sites will be filled up by using the list of quantities as basic data and according the agreed work sites. (Fig. 10)

COMPANY: NBR
DISTRICT: OULU
PROJECT: ROAD NO. 373

LIST OF QUANTITIES/~~WORK SITES~~ Date: 1980-03-24 Planners: [illegible] PAGE: ____

	COST CODE Number	SITE No	COST CODE NAME	LOCATION ON THE ROAD CHAINAGE	Quantity	Unit of quantity	COMMENTS
	1110		Removal work	1340	1	piece	hut
	1120		Clearing work	140 – 2100	24630	m^2	
	-11-		-11-	2320 – 2520	2400	m^2	
	-11-		-11-	2640 - 2740	1660	m^2	
	1120			TOTAL	28690	m^2	
	1310		Drainage	160 - 1120	380	m^3 solid	
	-11-		-11-	1360 - 2120	860	m^3 solid	
			E. T. C.				

COMPANY: NBR
DISTRICT: OULU
PROJECT: Road no. 373

LIST OF ~~QUANTITIES~~/ WORK SITES Date: 1980-11-27 Planners: PAGE ____

	COST CODE Number	SITE No	COST CODE NAME	LOCATION ON THE ROAD CHAINAGE	Quantity	Unit of quantity	NOTIFICATIONS
01	1110	01	Removal work	1340	1	piece	Hut 3 x 6 m, timber
01	1120	01	Clearing work	140-2100, 2320-2520	27030	m^2	old road
01	1120	02	Clearing work	2640 - 2740	1660	m^2	stripping of topsoil
			"				
			"				
			"				
01	1331	01	Culverts, concrete	480, 550	32	m	ø 600 mm class A
01	1331	02	Culverts, concrete	2160	21	m	ø 1200 mm class B
01	1334	01	Culverts, sideroads	140 - 2740	88	m	ø 500 mm
			E. T. C.				

Figure 10. List of quantities and list of work sites

3.52 Planning the work sites

The work site plans are to prepared of all the work sites mentioned in the lists of work sites for the total duration of the project.

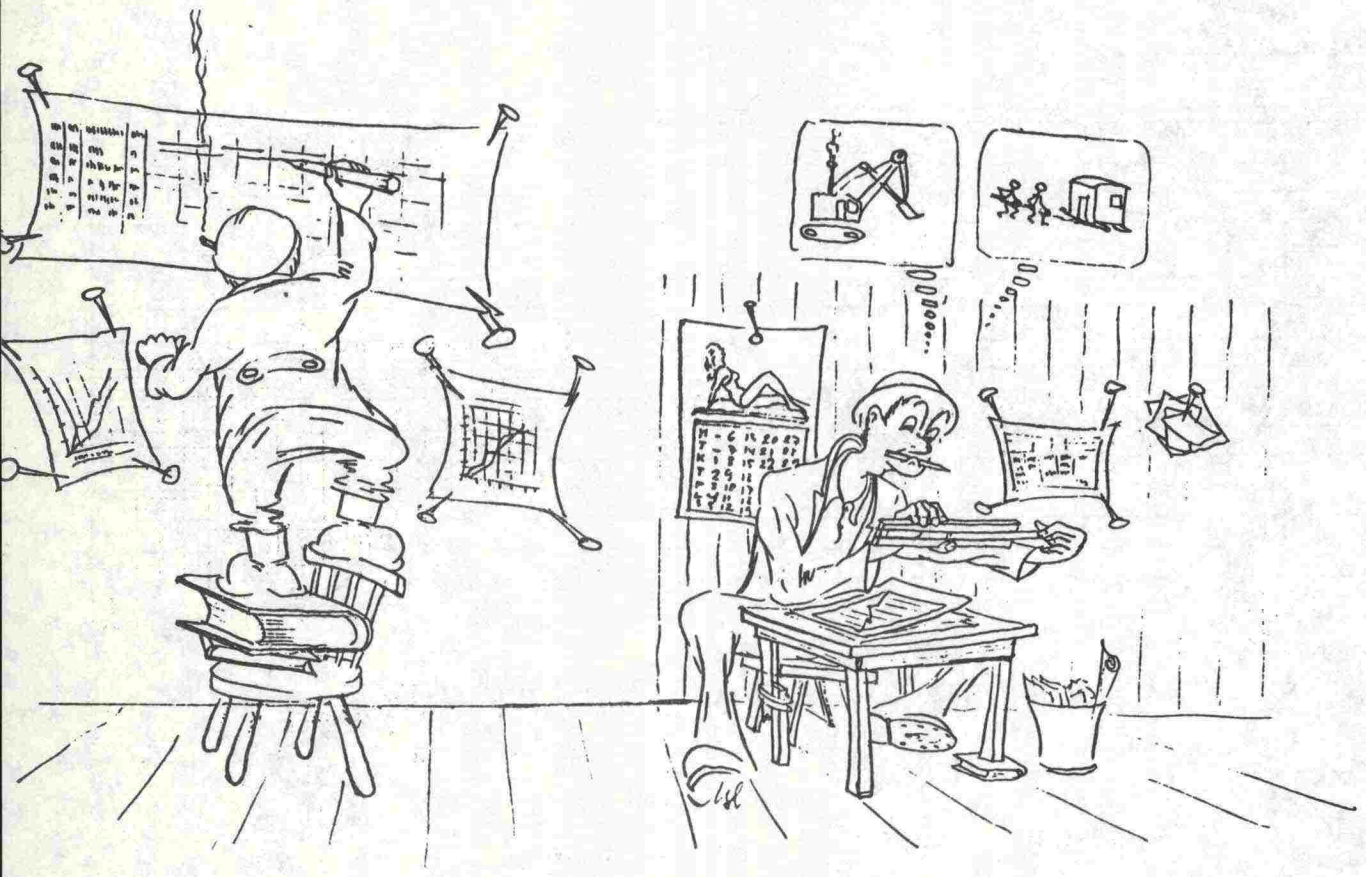
When planning the work sites one must:

- figure out the quantities of the work sites
- choose the best suitable work methods and resources
- calculate the durations and costs.

In the final planning the site manager is responsible for the work planning.

The work site planning process is explained more thoroughly in chapter 4.

The unit prices and quantities that are calculated at this stage of the planning process are the base for control reports.



3.53 Project plans and programs

The project plan is prepared from data collected from the work site plans. In principle the project plan is a bar-chart type schedule which is supplemented with resource data.

The plan is a basis for the graphic reporting and as a control tool it will give a clear picture of the project.

In additon the plan will serve as source of information for interior and exterior communication.

From the project plan the following plans are drawn up:

- budget
- organization plan
- procurement plan.

The process of drawing up the project plans is shown below in fig. 11.

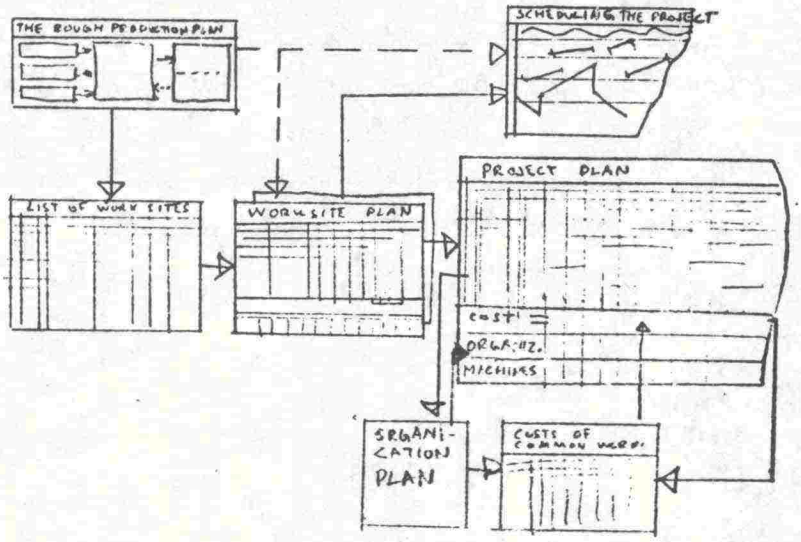


Figure 11. The making of the project plan

Scheduling the project and cost calculations

Basic data for scheduling are

- rough schedule
- work site plans which include
  - durations
  - costs
  - resources
  - quantities and subtargets

The necessary data for scheduling can be collected from the drawings and other documents and visits on site.

The purpose of the scheduling is to minimize the total cost of the project under prevailing restraints. Scheduling means that alternative calculations should be made in order to find out the most profitable timing and sequence of the activities of the project. Scheduling the activities will settle the distribution of cost, labour and resources for different periods of construction.

The various types of schedules are presented in chapter 6.

If the scheduling work is quite simple the most convenient type of schedule is bar-chart. If one will find out the location and the direction of the activities and timing on route a time-chainage-type of schedule is good for that. The network-type of schedule is suitable, if one will find out the sequence and dependencies of the activies and also the critical activities.

The data from these schedules will be put into the project plan.

Scheduling will be done as follows:

- allocate on the schedule those activies which have certain deadlines (fixed dates)
- allocate on the schedule those activities which are of great significance in respect of timing (critical activities, critical path).
- allocate on the schedule those activities which have no fixed dates on timing. With these one may for example level the use of labour etc.

The costs and other resources of the activities will also be allocated on the schedules. The data is collected from the work site plans.

Organization plan

The purpose of the organization plan is to find out the personnel needed for the project and its tasks and responsibilities.

The organization of the project must work as one efficient unit. The operative relations between different parts of the organization must be defined clearly. The organization plan is drawn up for the whole duration of the project and it is divided into one-month periods.

In the organization planning the number and the tasks of the technicians, foremen, clerks and laboratory workers are presented.

The number of the personnel is marked on the project plan as shown in fig. 14. This part of the plan is also the personnel plan of the project.

The organization plan will be prensented as shown in fig. 12.

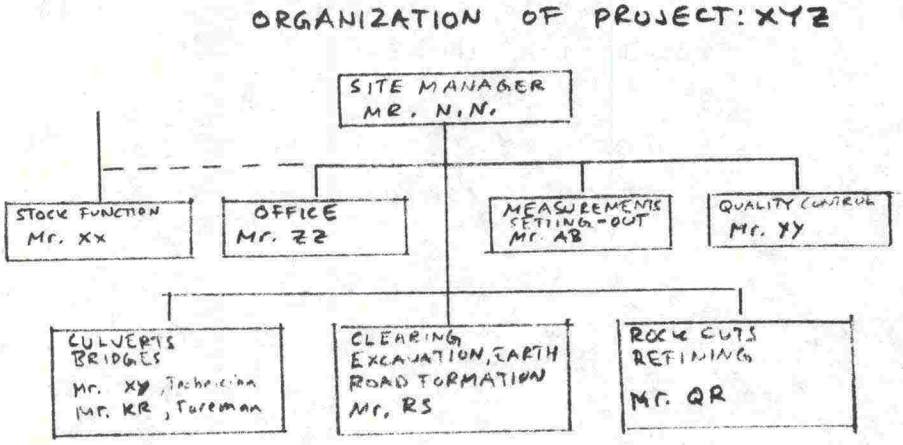


Figure 12. The organization plan

Planning of the common cost

The common costs are quite a big part of total costs of the project (in NBR about 20%). They should be planned carefully according to the cost code book.

Most of the data needed is found from the project plan. Also the cost of the use of the camp area etc. should be calculated.

The common costs are planned for total duration of the project. The plan may be made on a budget sheet as shown in fig. 13.

COMMON COSTS (PLANNED)

COMPANY: NBR

DISTRICT: No 72 NAME:

PROJECT: No 393 NAME:

YEAR: 19 84 - 19 81

DATE: 30.10 PLANNED: COST INDEX

DATE: CHECKED: XE APPROVED:

		COST CODE NO.		WORK	QUANTITY UNIT	JANUARY Quantity	JANUARY COST	FEB Quantity	FEB COST	MARCH Quantity	MARCH COST	APRIL Quantity	APRIL COST	MAY Quantity	MAY COST
1	R			Equipment, hires			1800		1800		1800		1800		1800
2	R			Equipment, transport			2500		500		300		300		300
3	R			Lighting and heating			1100		1600		800		800		700
4	R			Cleaning			2200		2700		2200		2200		2200
5	R			Others			300		300		300		300		300
6	R	00	9210	00 CAMP AREA			10200		8100		8100		8100		
7	R														
8	R			Health and other services			300		100		—				
9	R			Transportation of workers			400		400						
10	R	00	9220	00 Social costs			100		50						
11	R														
12	R			Work site managers	3x5000		15000								
13	R			Foremen, supervisors	3x4500		13500								
14	R			Laboratory workers	1		4500								
15	R	00	9230	00 SITE MANAGEMENT			33000								
16	R														
17	R			Clerks			5								
18	R			Office equipment											
19	R			Accounting center											
20	R			Telephone											
21	R	00	9240	00 OFFICE EXPENSES											
22	R														
23	R														
24	R														
25	R			E.T.C											
26	R														
27	R														
28	R														
29	R														
30	R														
31	R														
32	R														
33	R														
34	R														
35	R														
36	R		9200	TOTAL			XXX		XXX		XX		XXX		XXX

RB2 TVH 732265 207×400 10000 12.77 187701808K-13/0806

Figure 13. The plan of common costs

Project plan

During the planning process one should check that the plan will statisfy the set objectives and restraints. If the objectives are not met, the plans have to be revised.

An example of a project plan is shown in fig. 14.

PROJECT PLAN

PERIOD	CODE	SITE CODE	WORK	UNIT	QUANTITY	UNIT COST	TOTAL COST	1977 SEPT	OCT	NOV	DEC	1980 JAN	FEBR.
01	1110	01	REMOVAL				150000					100 000	
01	1120	01	CLEARING	m^2	28450	2,60	73 970	4000	6000	7000	7000	1000	
								10400/3	15600/4	18200/4	18200/4	2600/1	
01	1120	02	—"—	m^2	3000	1,85	5550						
									400	500	300		
01	1310	01	DITCHING	m^3	2120	7,00	14840		2800	3500	2100		
01	1322	01	CULVERTS	m	200	200,00	40000	20	100	80			
			E.T.C.										
COST OF THE WORK (1000)							2'435	142	183	190	128	220	
COMMON COSTS (1000)							736	66	61	63	41	58	
TOTAL COST (1000)							2'211	208	244	253	189	278	
PERSONNEL													
Technicians								3	3	3	3	3	
Foremen + lab.								3	3	3	3	3	
clerks								1	1	1	1	1	
Stock + Labourers								19	20	20	20	19	
					TOTAL			26	27	27	27	26	
MAIN MACHINES													
BULLDOZER (18 ton)													
WHEEL LOADER (9 ton)								1					

Figure 14. The project plan

3.6 PLANNING AT BEGINNING OF A WORK SITE

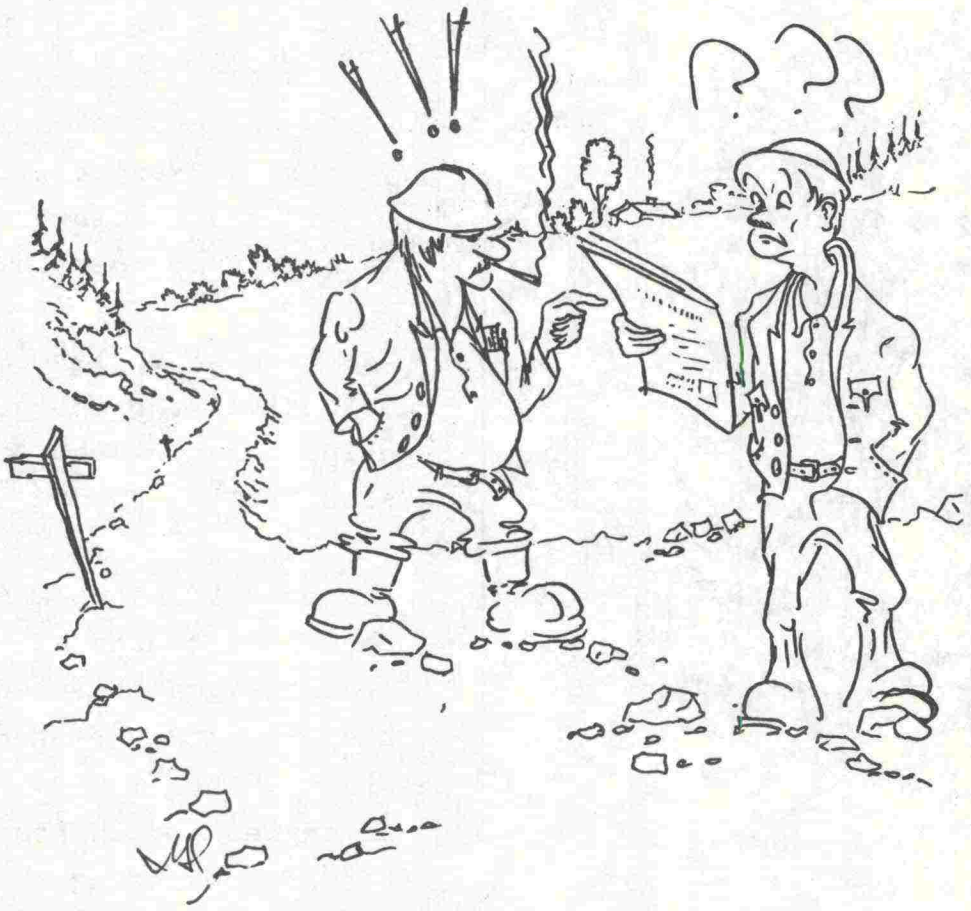
When the site manager sets objectives to the work site foreman he should check if the work can be done according to the schedule in the project plan.

At the same time the site manager will write the planned distribution of quantities, cost and labour on the schedule part of the work site plan sheet.

The work site plan which has been made during the final planning will be revised by the foreman to meet the current circumstances. If he has not made the work plan himself he will get as a frame the plan from the site manager. This plan should also be revised if necessary.

If the foreman thinks that the plans should be changed, he should negotiate about the matter with the site manager.

After the plan has been revised the foreman will draw up a objective curve or other type of schedule suitable for control.



4. WORK SITE PLANNING PROCESS

The purpose of work site planning is:

- to find out the most economical and technically possible way of carrying out the works on a site
- to present on paper a model for carrying out the construction works according to the limits and frames set to the site

The work site plan sets the objectives for the site and it helps managing the site succesfully.

The results of work site planning should be presented so that they can be used for making the production plan of the whole project and for reporting. Tables, schedules and charts are suitable for of presenting a production plan and work site plans.

Work site planning should be based on a thorough study of the work site area, terrain, and local conditions. When getting acquinted with the conditions the planner should notice for instance:

- what type of machinery can be used
- what are the methods that could be used
- the quality of earth material, water and other nature resources
- the existing roads and need for access road
- the existing electric cables and pipe lines on the work site area
- possible places for offices and social barracks and WC
- ground water supply,
- weather conditions during the site works (floods, rain season)

The production data files are a good help in making the work site plan (see charpter 6.1).

4.1 THE BASIC DOCUMENTS

As back ground for work site planning the planner should be able to use:

- general specifications and contract program
- product plan drawings and specifications
- list of work sites, from which the quantities and exact bounderies of the work site can be found
- the rough and final production plans of the project, from which the planner can find:
  - the estimated duration and schedule for this site
  - the relationship between this site and other sites on the project
  - estimated main machinery and organization
  - orders for goods and materials made earlier
- Bill of Quantities

4.2 DETERMINING THE QUANTITIES OF THE WORK SITE

The quantities to be handled must be cleared more specifically for work site planning than they can be found in the general bill of quantities. Also the units should be changed from theorectical quantity units to actual units.

In the NBR model the quantities and units of a work site can be found from the list of quantities (page 43).

The quantities that are found in the list of quantities are usually expressed in the theoretical quantities (measured from drawings and bill of quantities). Because it is almost impossible to calculate the exact costs according to theoretical units, the quantities should be changed into actual work quantities (the quantity of concrete wall is 10 m^3 and the quantity of concrete needed for making the wall could be 11 m^3 because of waistage and spreading). There are also quantities needed to determine, that are not expressed in the bill of quantities for instance frame work.

Determining the actual quantities can be done by using (wastage and material deformation) coefficients (production data files).

When determining the actual quantities the planner must take the weather into consideration.

The beginning, ending and maintaining works must be taken in to the calculations also, because they take time, even though there are no quantities.

COMPANY: _____ LIST OF QUANTITIES/ WORK SITES PAGE _____

DISTRICT: _____ Date: _____ Planner: _____

PROJECT: _____

	COST CODE Number	SITE NO	COST CODE NAME	LOCATION ON THE ROAD CHAINAGE	Quantity	Unit of quantity	COMMENTS -

During the actual construction works it must be taken care that the planned quantities will not be increased during the works without good reason. This can be done by self-reporting.

4.3 CHOOSING THE WORK METHODS AND RESOURCES FOR THE WORK SITE

One of the main purposes of work site planning is to find suitable methods and machinery for sites construction works and choosing the most economical way of carrying out the works of the site.

Choosing the best methods and machinery for the site depends on

- there are many different available machines for the site
- the existing machinery of the company
- the working conditions and materials
- the estimated duration of the site
- the schedule of the project.

Choosing the methods and machinery must be based on alternative calculations. The planner has to calculate the costs for the work site according to each comparable method. The most economical (cheapest) method should be the choice. But the work site planner must also take into consideration the economy of the whole project and the risks that are in his choice.

4.4 SCHEDULING THE WORK SITE

One of the most important steps of work site planning is scheduling of the works. In scheduling the planner must calculate:

- the duration of each work or activity in the work site
- the need of machinery and labour for each work or activity
- the work quantities for each month of the duration

In determining the schedule for each work element in the site the planner must take into consideration all the relationships between different activities. This way the planner can use all the available resources continously and the degree of utilization will be high.

The suitable scheduling techniques will be presented later on this book, chapter 6.

At this stage the planner should write down on the work site plan sheet:

- quantity (theoretical & actual)
- machinery
- performance of the machines (out put)
- the duration for each activity in days

The table and an example are presented on page 46, 47

COMPANY:

WORK SITE PLAN

DISTRICT: _____ DATE ___/___/____ PLANNER: _____

PROJECT: _____

LOCATION (Ch.) _____ THEOR. QUANTITY | Quantity: | Unit:

WORK ELEMENT/ OPERATION	MACHINE	DATA FILE No	PERFORMANCE	QUANTITY	UNIT	HAULING DISTANCE	DURATION (days)	UNIT COST	TOTAL COST	Comments
					TOTAL					COST INDEX

SCHEDULIN THE WORK SITE

MONTH	January	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
QUANTITY Planned												
QUANTITY Actual												
COSTS												
LABOUR												

TIE- JA VESIRAKENNUSHALLITUS

COMPANY: MECCO

WORK SITE PLAN

DISTRICT:

DATE 1/4/1980

PLANNER: P. Rantanen

PROJECT: Dar - Tanga

PROJECT no.		COST CODE 1510	
Quantity: 16000		unit: m^3 solid	actual

LOCATION (ch.) THEOR. QUANTITY

WORK ELEMENT/ OPERATION	MACHINE	DATA FILE NO	PERFORMANCE PER DAY	QUANTITY	UNIT	HAULING DISTANCE	DURATION (days)	UNIT COST	TOTAL COST	COMMENTS
CLEARING WORKS	BULL DOZER 21 tons	5021	1700	5000	m^2	—	3			5000 m^2
— " —	5 MEN						(3)			
LOADING	LOADER 9 tons	5012	1000	25000	m^3-l. a	2 km	25			25000 m^3 loose actual
HAULING	7 TRUCKS	5028					(25)			
BACK FILLING	BULL DOZER 8 tons						(25)			
SMOOTHING & LEVELLING	Grader 14 tons						(5)			
COMPACTING	vibratory roller						4			
WATERING	1 TRUCK						(4)			
Man work	3 MEN						(38)			
Material				25000	m^3-l. a					
Beginning & Ending							2			
WORKS										
					TOTAL		38			COST INDEX

SCHEDULIN THE WORK SITE

MONTH	January	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
QUANTITY Planned												
QUANTITY Actual												
COSTS												
LABOUR												

4.5 CALCULATING THE COSTS FOR THE WORK SITE

After the planner has been able to fill the table with quantity, machines and performances he has to estimate the actual prices for machines, labour and material.

Cost calculating starts by estimating the unit cost for each work element either on hourly cost basis or on unit cost basis and this cost is written down into the unit cost section . The costs of each work element are calculated by multiplying. The total cost for the work site is calculated by adding the costs of each work element. The final unit cost for the whole site can be calculated by dividing the total cost by theoretical quantity of the site.

Into the lower part of the scheduling sheet the planner should write down the quantity, cost and labour for each mont separately.

On page 50 there is an example of work site plan .

COMPANY: MECCO

WORK SITE PLAN

DISTRICT:

DATE 1/4/1980

PLANNER: P. Rantanen

PROJECT: Dar - Tanga

PROJECT no.		COST CODE 1510	
Quantity: 16000		unit: m^3 solid	actual

LOCATION (Ch.) THEOR. QUANTITY

WORK ELEMENT/ OPERATION	MACHINE	DATA FILE NO	PERFORMANCE PER DAY	QUANTITY	UNIT	HAULING DISTANCE	DURATION (days)	UNIT COST	TOTAL COST	COMMENTS
CLEARING WORKS	BULL DOZER 21 tons	5021	1700	5000	m^2	—	3	167,0	4020	5000 m^2
— " —	5 MEN						(3)	75,0	6000	
LOADING	LOADER 9 tons	5012	1000	25000	m^3-l.a	2 km	25	72,0	16 120	25000 m^3 loose actual*
HAULING	7 TRUCKS	5028		"			(25)	(3,8)	94.750	⇐ unit cost / m^3
BACK FILLING	BULL DOZER 8 tons			"			(25)	47,0	9800	
SMOOTHING & LEVELLING	Grader 14 tons	50		6000	m^2		(5)	75,0	7010	
COMPACTING	vibratory roller			6000	m^3		4	72,0	1740	
WATERING	1 TRUCK			38	m^3		(4)	61,0	1460	
Man work	3 MEN						(38)	45,0	9300	
Material				25000	m^3-l.a			0,45	11250	
Beginning & Ending							2			
WORKS								5 3 L V L 2 J A		
					TOTAL		38		157480	COST INDEX

SCHEDULIN THE WORK SITE

MONTH	January	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
QUANTITY Planned												
QUANTITY Actual												
COSTS												
LABOUR												

5. THE BUDGET OF A PROJECT

The budget for a project is made according to the production plan of the project. The budget is usually made on specified form. All the quantities and costs in the budget must equal to the production plans. When the budget is signed by the project manager and site manager they agree that the budget is an economical objective for the project.

The front page of the budget includes general information about the project for the management. Costs and quantities of different works (cost codes) and labour and schedule are presented on the front page with other general information of the project (see page 52). The front page is made for the whole duration of the project and it includes all the costs of the project.

The next two pages of the budget are made on more accurate monthly basis. The quantities and costs are scheduled for every month of the year and they are presented on a specified table. These two pages form the basis for reporting of the project. All actually performed quantities and costs will be compared to the budget monthly. These more accurate two pages of the budget are made annually, if the project lasts for more than a year.

The last page presents the quantities and costs that have already been done and what is still left to do. Page four is revised annually.

The budget is made just before the project starts and it is made for the whole duration of the project.

Budget page 1

COMPANY   CONSTRUCTION PROJECT BUDGET 19 -19   Page: RB 1

DISTRICT	No	Name:	Date:	Planner:	Forec:	Checked:	Date:	Approved:
PROJECT	No	NAME:						

DESCRIPTION OF THE PROJECT (works, cross-section, pavement, concrete...):

COSTS AND LABOUR

ANNUALLY	19	19	19	19	19	19	TOTAL
1000 $							
LABOUR							

MONTHLY 19 to 19

	1	2	3	4	5	6	7	8	9	10	11	12
1000 $												
LABOUR												
1000 $												
LABOUR												

COSTS AND QUANTITIES

COST CODE	WORK	UNIT	QUANTITY	UNIT COST	1000 Sh.	SCHEDULE

-52-

RB 1

1277077627-13/10211

Budget page 2

COMPANY ?

CONSTRUCTION PROJECT BUDGET

YEARS 19□-19____ RB2 Page

DISTRICT No

PROJECT No

NAME ?

DATE? PLANNED ?

COST INDEX ____ / ____

NAME :

DATE: CHECKED ?

DATE ____ APPROVED ?

	.		COST CODE NO.	LOC SITE NO.	WORK	QUANTITY UNIT	JANUARY		FEB		MARCH		APRIL		MAY		JUNE	
							QUANTITY	COST	QUANTITY	COST	QUANTITY	COST	QUANTITY	COST	QUANTITY	COST	QUANTITY	COST
1	R																	
2	R																	
3	R																	
4	R																	
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31	R																	
32	R																	
33	R																	
34	R																	
35	R																	
36	R																	

RB2 TVH 732266 297x400 10000 12.77 187701856K-13/9806

Budget page 3

COMPANY

CONSTRUCTION PROJECT BUDGET

YEARS 19☐ - 19____ RB3 Page —

DISTRICT No NAME: DATE: PLANNER: COST INDEX

PROJECT No NAME: DATE: CHECKED: DATE: Aproved:

		COST CODE no.	WORK SITE no.	Quantity unit	July		August		September		October		November		December		Annual total		AVERAGE UNIT COST
					Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	
1	R																		
2	R																		
3	R																		
4	R																		
5	R																		
6	R																		
7	R																		
8	R																		
9	R																		
10	R																		
11	R																		
12	R																		
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27	R																		
28	R																		
29	R																		
30	R																		
31	R																		
32	R																		
33	R																		
34	R																		
35	R																		
36	R																		

-54-

RB3 TVH 732267
297x400 10000 12.77 187701857L-13/9807

Budget page 4

CONSTRUCTION PROJECT BUDGET

COMPANY:

DISTRICT No

PROJECT No Alcitusv. NAME:

NAME: DATE: PLANNER:

DATE: CHECKED:

YEARS 19 - 19 RB4 Edge

COST INDEX

DATE: APPROVED:

			COST CODE No	WORK SITE NO.	WORK	QUANTITY UNIT	YEAR 19 — CONSTRUCTION QUANTITY	COST	UNIT COST	THE UNIT COST FIG. ARE LEFT TO RIGHT	YEAR 19 QUANTITY	COST	YEAR 19 QUANTITY	COST	YEAR 19 QUANTITY	COST	YEAR TOTAL QUANTITY	COST
1	R1																	
2	R1																	
3	R1																	
4	R1																	
5	R1																	
6	R1																	
7	R1																	
8	R1																	
9	R1																	
10	R1																	
11	R1																	
12	R1																	
13	R1																	
14	R1																	
15	R1																	
16	R1																	
17	R1																	
18	R1																	
19	R1																	
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31	R1																	
32	R1																	
33	R1																	
34	R1																	
35	R1																	
36	R1																	

RB4 TVH 732268 297x400 10000 12.77 187701888M 13/9806

6. SOME INSTRUMENTS FOR MAKING THE PRODUCTION PLAN

6.1 PRODUCTION DATA FILES

In order to make the production plan for a site or a project the planner needs data about

- material
  - diggability
  - material coefficients (swelling.....)
  - wastage
  =

- working methods
  - instructions for use
  - restrictions for the method
  =

- performances
  - performances for methods and machinery and trucks (out put m^3/day)
  - rough performances for works (cost codes)
  =

- costs
  - unit cost of works
  - costs of material
  - costs of machinery
  =

This type of production data the planner can get

- by experience
- from hand books
- cost controlling reports
- work study
- from manufactors
- from production data files of a company.

Production data should be used when choosing the methods and machinery and when calculating the costs.

The best way of getting production data is company's own production data file, that is created by using cost reporting and work study. This type of file is ment for the use of company's all projects and sites.

Company's own production data file guarantees a good reliability for the data and for the work plans. Production data helps production planning and it gives all work plans an equal basis for comparing and this data can be used also for reporting.

There are examples of production data forms that are taken from the NBR earth works production data file (page 58).

TIEN TEKEMINEN
TS
TYÖNSUUNNITTELU

Työnvaihetiedot

Excavation of Earth soil

Performances for excavating and loading

REK NO	SIJOITUS
5024	B.1
LAATIJA	AIKA
TVH/Rrt	1.78

MACHNES, EXCAVATOR (KKH), LOADER (KUP), DOZER (PT)

MATERIAALITIEDOT (GEO) MATERIAL DIGGABILITY

HELPOT: Easy — liejut, turpeet (E1 - E3), hiekat (K1), sorat (K2) savet (H1), siltit (H2)

KESKINKERTAISET: Medium — keskitiiviit, kivettömät ja kiviset moreenit (M1 - M2) somero (K3)

VAIKEAT: Hard — tiiviit moreenit, runsaskiviset moreenit (M3)

PERFORMANCE PER DAY

Operation	Resource	MATERIAL DIGGABILITY			OTETTAVA HUOMIOON Notice
		Easy	Medium	Hard	
Excavation and Loading	KKH 11 K	510	330	210	Roudan rikkominen suoritettava erillisenä työnä, jos sen paksuus > 0,3 m
	14	570	400	300	
	17	650	480	390	
	21-25	760	580	500	
	30	830	720	620	
(m3ktr/tv)	KUP 06-07	670			
	09-10	820	600		
	13	1040	740		
	16	1200	850		
	19-22	1450	1050		
	30		1400		
Loading from a Borrow pit KUORMAUS VARAMAA-PAIKASTA	KUP 06-07	710			Oletettu, että routaa ei esiinny lainkaan
	09-10	870	660		
	13	1100	800		
	16	1260	940		
	19-22	1540	1180		
	30		1540		
(m3ktd/tv)	KKH 11 K	540	350		
	14	600	450		
	17	670	530		
	21-25	800	640		
	30	880	750		
LOADING FROM LOOSE MATERIAL STORAGE (m3ktr/tv)	KUP 06-10	810	620		Irrotus ja kasaus puskukoneella
	13-16	1150	870		
	19-30	1600	1300		
BULLDOZER CUTTING LOOSE (m3ktr/tv)	PT 21 R		750	410	Sisältävät myös kasaanpuskun ja luiskien viimeistelyn
	35		1050	600	

Häiriöajat tulee ottaa huomioon laskemalla kuukauteen 20 tp.

TIEN TEKEMINEN TS TYÖNSUUNNITTELU

Työnvaihetiedot

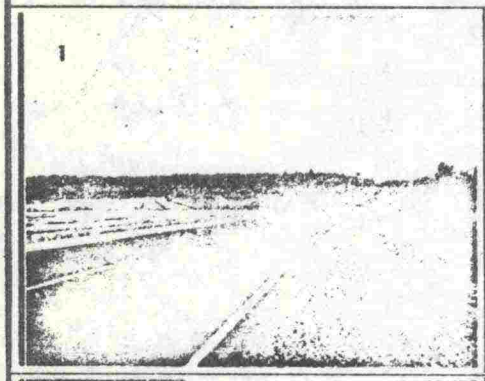
Hauling earth masses with truck
Massojen kuljetus

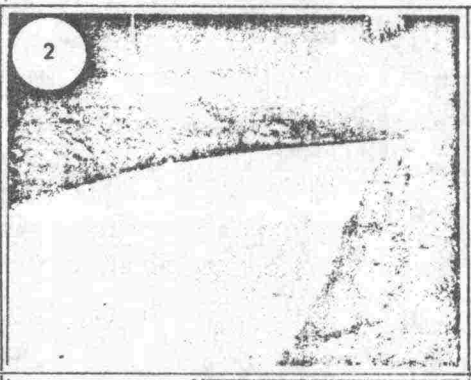
Kuljetuskaluston valinta

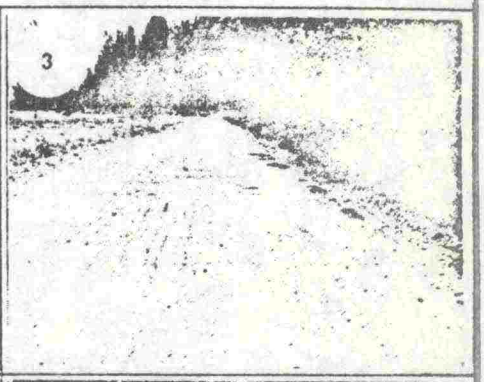
Choosing the number of trucks

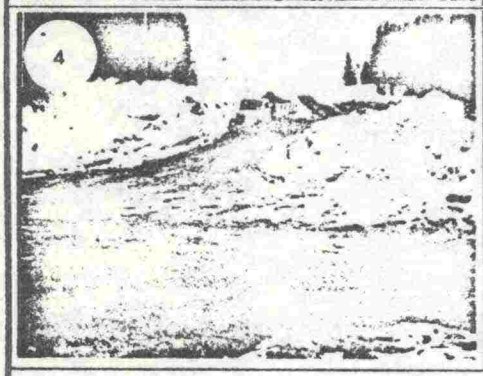
REK. NO	SIJOITUS
5037	B.2.
LAATIJA	AIKA
TVH/Rrt	12.77

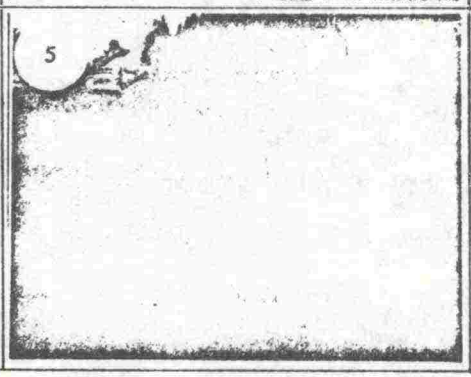
ROAD CLASIFICATION AND SUITABLE HAULING EQUIPEMENT

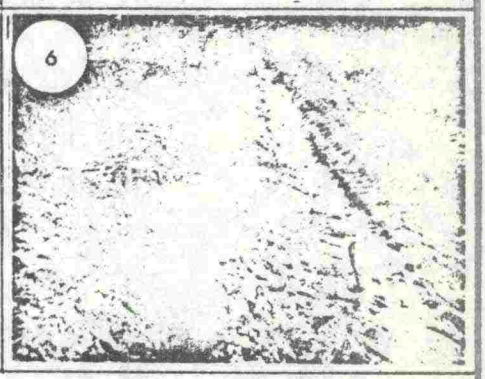


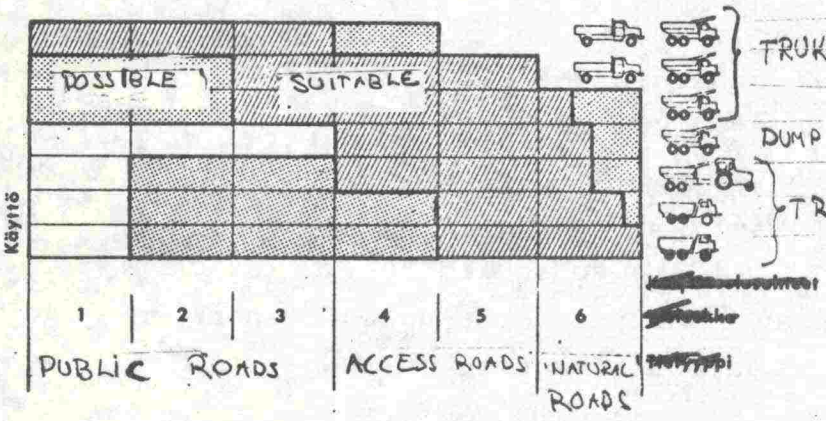












Public roads 1,2,3
Access roads 4,5
Natural roads 6

Performance per day (m³itd / day)

The performance per day for one single truck with a load of 8 m³itd

	Average hauling distance (km)							
	0,5	1	2	5	8	10	15	25
Puplic roads	330	230	180	140	110	95	70	55
Access roads	300	210	170	120	90	75	55	
Natural roads	230	170	95					

6.2 SCHEDULING TECHNIQUES

Choosing the right type of schedule affects very much succesful production planning and managing the project.

All project are different from each other. In one project the dependencies between different works can be the most important thing. In another project the duration and scheduling the works into some specific time limits is most important. In some projects the location (chainage) can affect scheduling very much.

The different scheduling techniques emphasize only one of these things and that is why it is important to choose the best schedule for each project.

6.21 Bar chart

In a bar chart schedule the planner presents all the works (or elements of the project) on the vertical axis. The horisontal axis is the time. The time scale has to be chosen so that all the scheduled activities can be drawn enough accurately. The use of resources (men and machines) is presented on the horisontal axis.

Bar chart is a good schedule, if the main thing in scheduling is the placing of works to certain dates or if it is important to get very stedy use of the machinery. Bar chart suits also well for planning of project's continuity.

If the project is simple and the works are very well defined bar chart is a natural choise for the schedule (see page 62).

BAR CHART

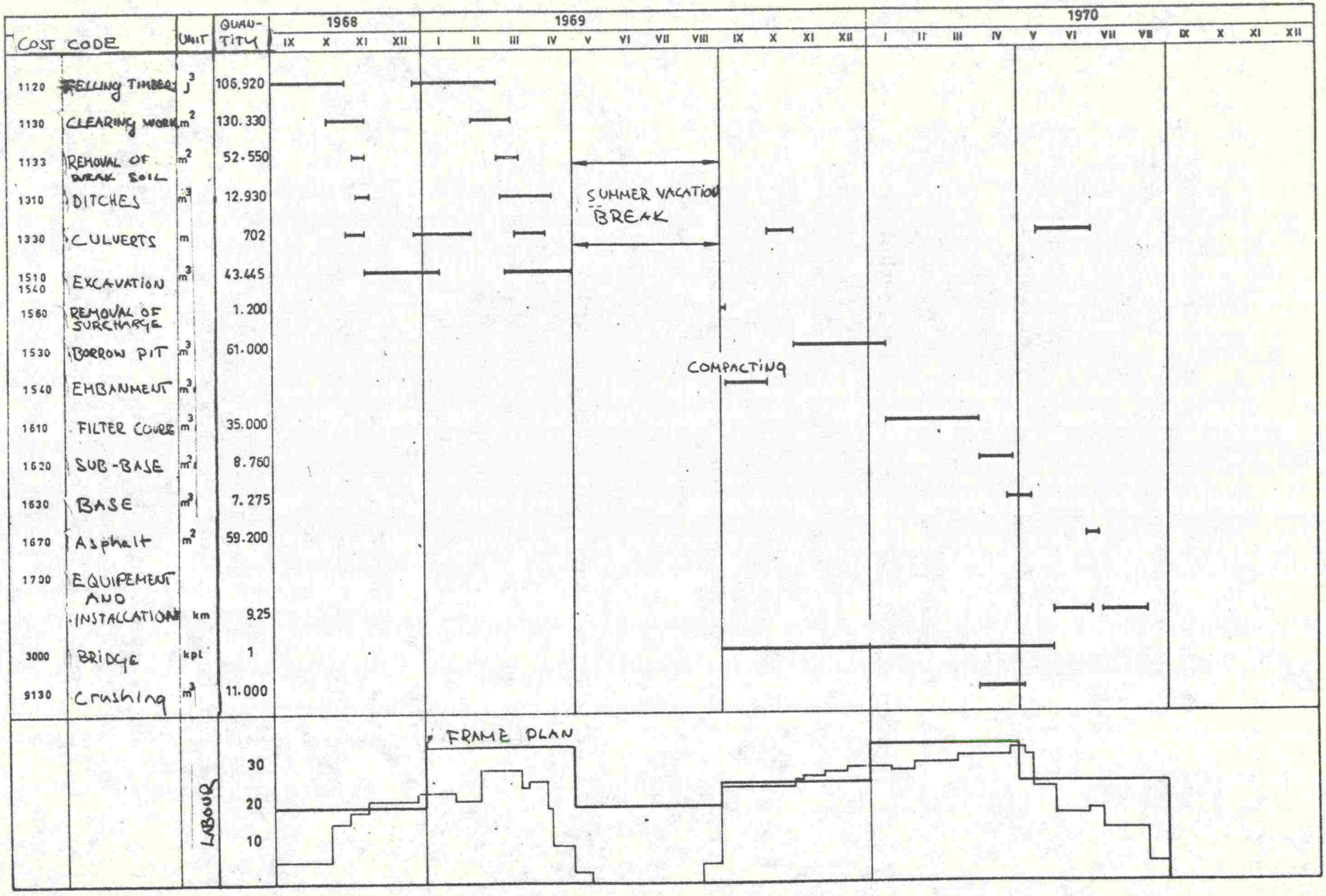


Figure 15. Bar chart schedule

6.22 Time-chainage chart

Time-chainage chart is a schedule that presents both the happening time and location of a work or an activity of the project.

Time-chainage chart suits very well all the road construction works or for contracting sky scrapers, pipe laying etc.

The time-chainage chart should be drawn on a form so that the vertical axis is the time and the horisontal axis is the chainage (location). The scales for both axises should be chosen with care, because it affects very much the usefulness of the schedule. The use of resources (labour and machines) should be presented on the vertical axis. See page 64.

6.23 Quantity-time chart (objective curve)

The quantity-time chart present the relationship between time and the quantities of a work. The vertical axis is the quantity of the work and the horisontal axis is time in days. The scale for both axises must be visually clear and large enough for the use of reporting.

The use of resources is presented on the horisontal axis below the chart.

Objective curve suits well for a work site schedule, because there is only one or few quantity units. It is also good for graphical reporting. See page 65.

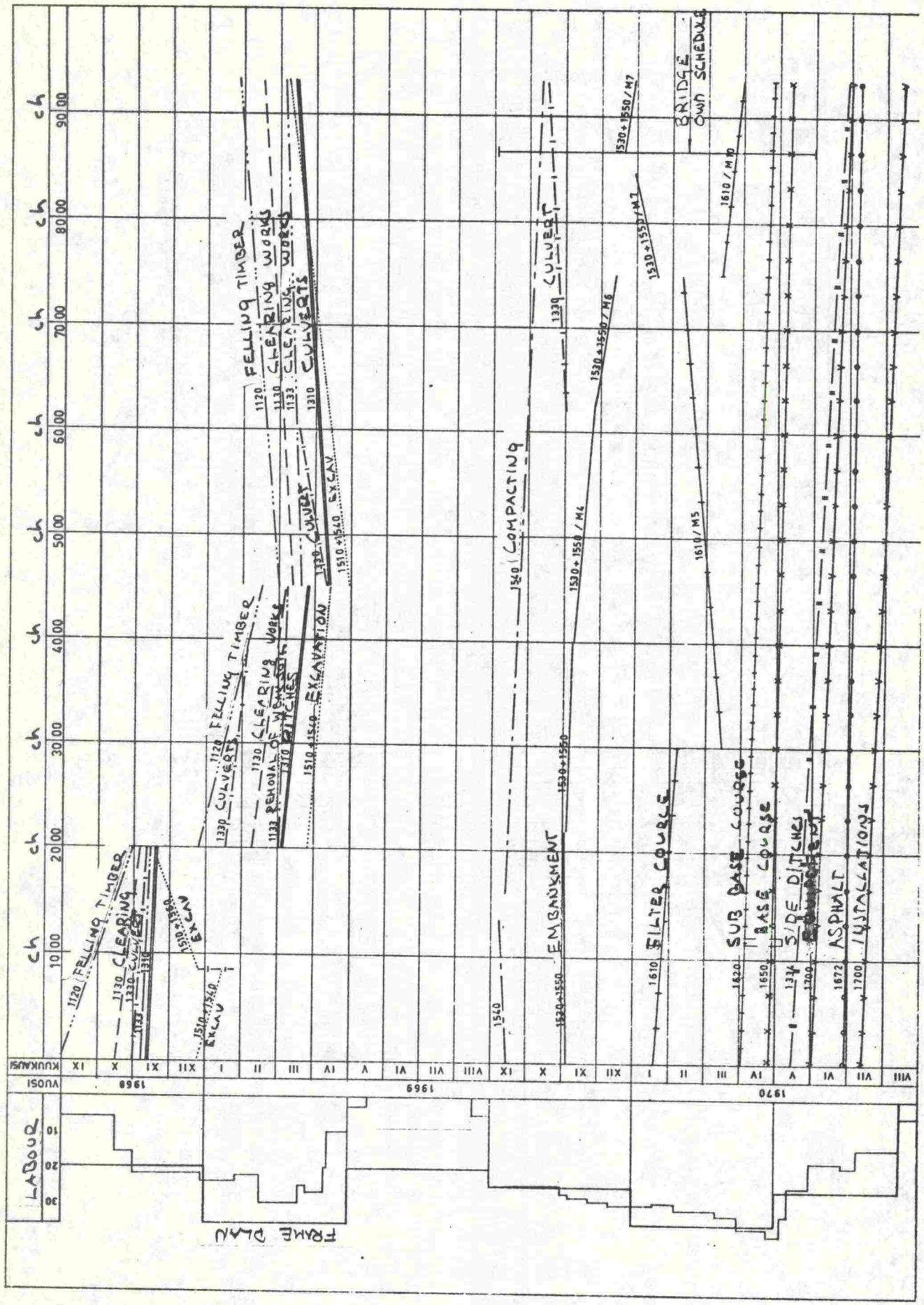


Figure 16. Time-chainage chart

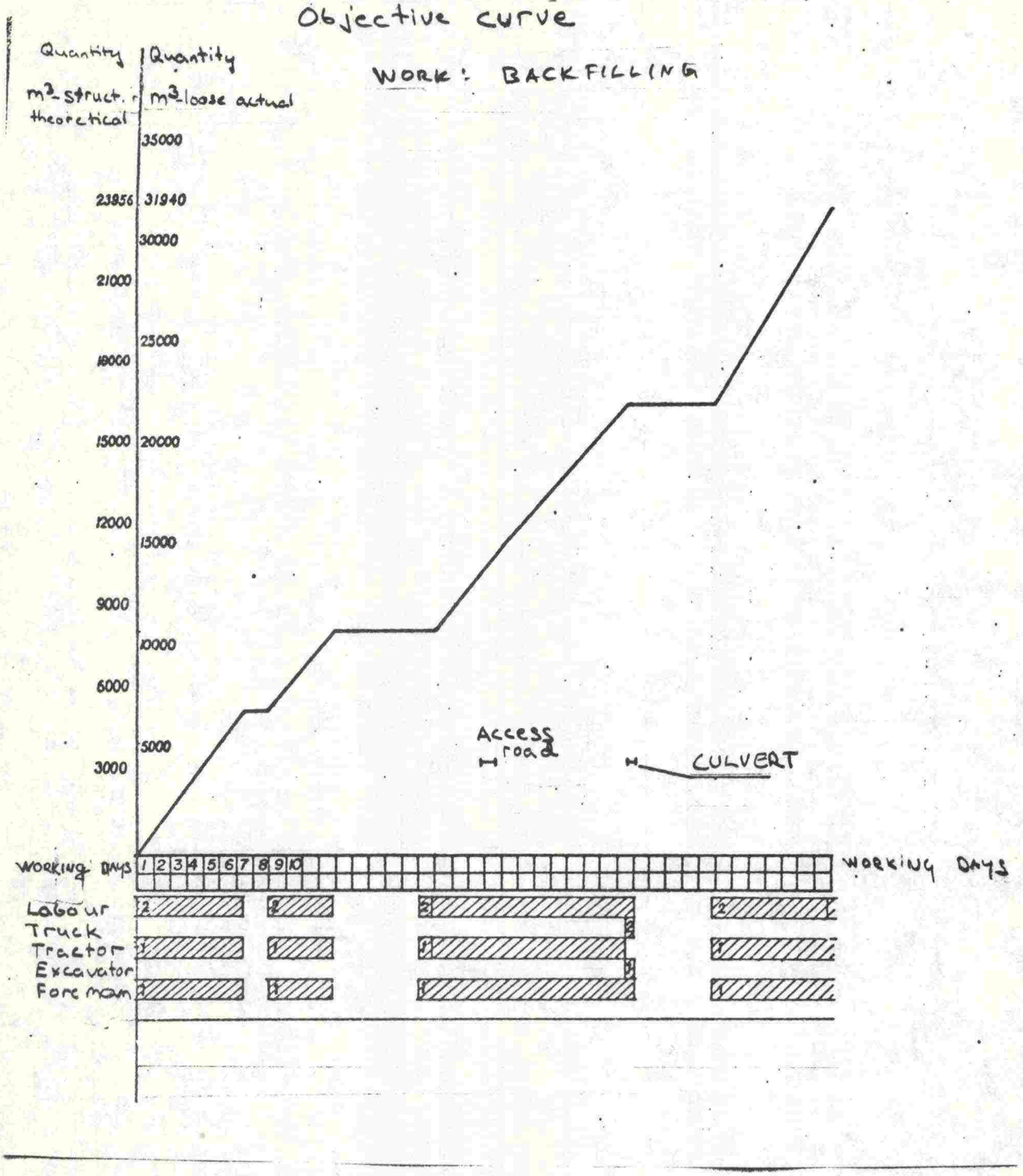
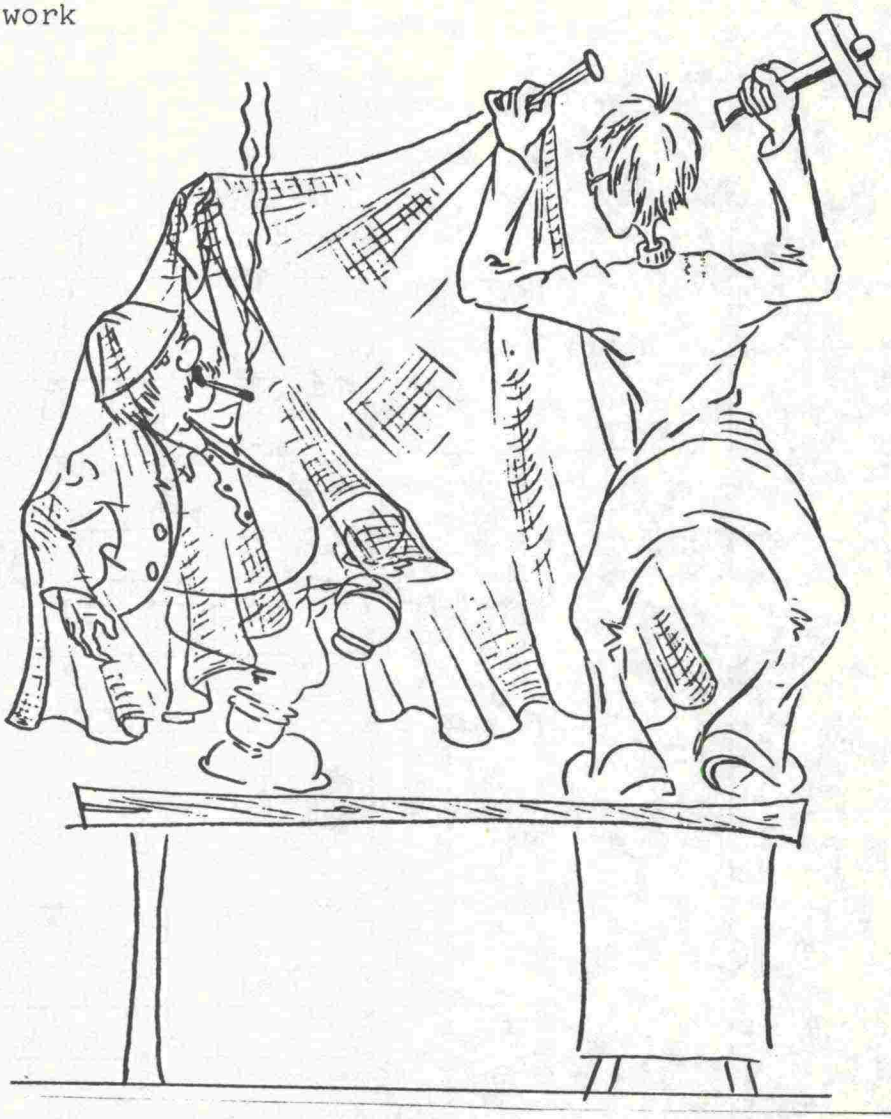


Figure 17. Quantity-time chart (objective curve)

6.24 Net work

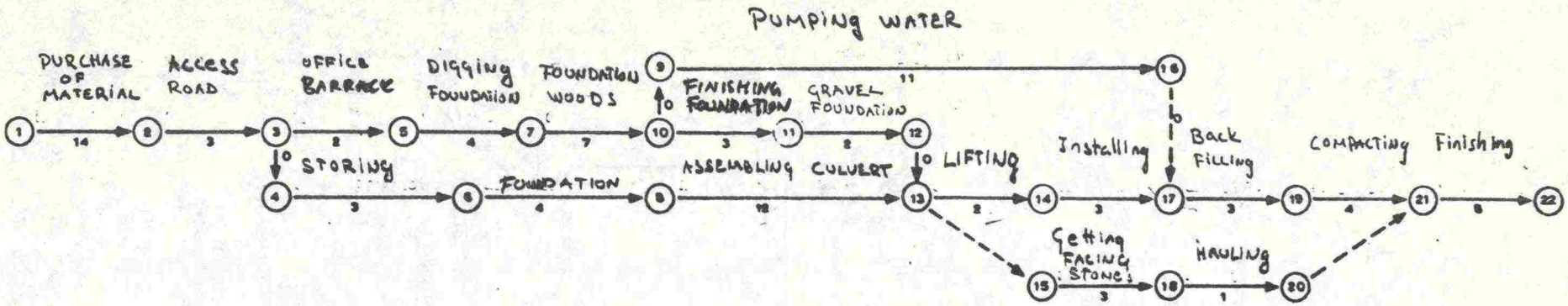


Network is a schedule that suits well for solving all the dependencies between different works and for getting steady use of resources and for optimizing the duration and cost of the project. The network clears out well all the critical works for the project and solves the float for each work (critical path method).

The network can be drawn as an activity-on-arrows or activity-on-nodes network.

In an activity-on-arrows network the works are presented by arrows and time is presented in the horisontal axis or only in calculations. The use of resources is marked under or on the arrows.

NET WORK SCHEDULE, MAKING STEEL PIPE CULVERT ∅ 1500 mm



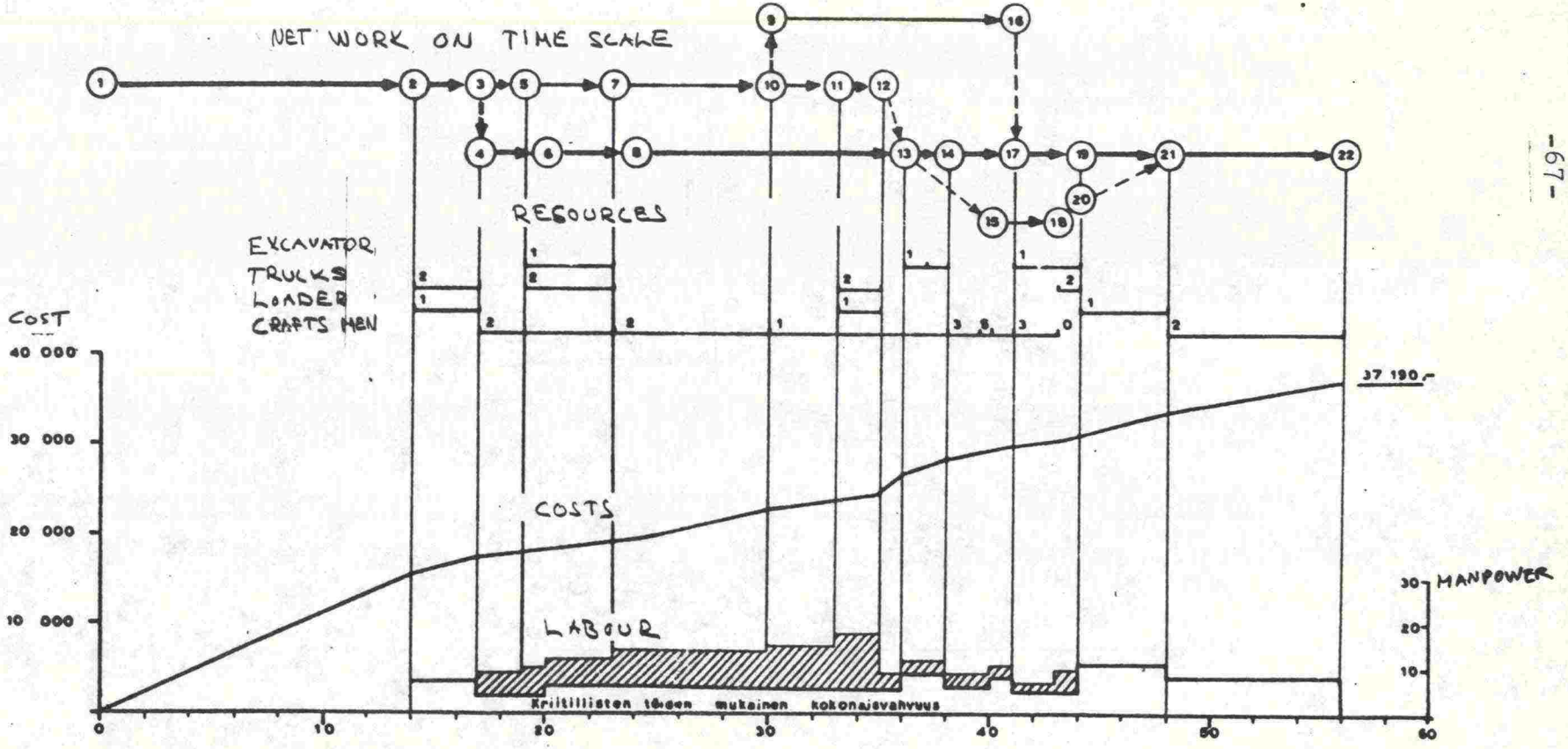


Figure 18. Net work

For production planning and scheduling the project is divided into smaller activities. Activities depend on some other activities, in respect of resources or sequence, and network takes these relationships into consideration. Network method can be used in large projects because it is useful for estimating

- duration of the project
- resource allocation
- resource restriction.

Network suits also reporting and preparing for conflicts and disturbance.

Network is the most complex scheduling method and needs most calculating and best education as background.